Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

SEPTEMBER, 1911.

THE TRUE STRUCTURE OF THE DIATOM VALVE.

By T. F. SMITH.

(Continued from page 293.)

FIGURE 14 is from the *inner* side of another valve, the first ever seen and taken, showing the fracture through undoubted perforations. The strongest argument hitherto for "beads" in the finer forms was that the fracture always ran between them, as the weakest part. Mr. E. M. Nelson, at the discussion in the Quekett Club, gave this testimony: "The difficulty has always been felt that in *formosum* they had never been able to see the holes; but now it was shown that there was, undoubtedly, a perforated membrane; they could take it and see for themselves that it was a perfectly plain thing; indeed, if this was not real, then he could only say that all other things were hocus pocus. With their very best lenses they had tried to find out about *formosum*. Mr. Smith had found this fracture, had shown it to him, and that at any rate the fracture did run through the holes." This extract is given here not in any spirit of self-glorification on the part of the present writer; but rather that so valuable a testimony should be added to strengthen his own.

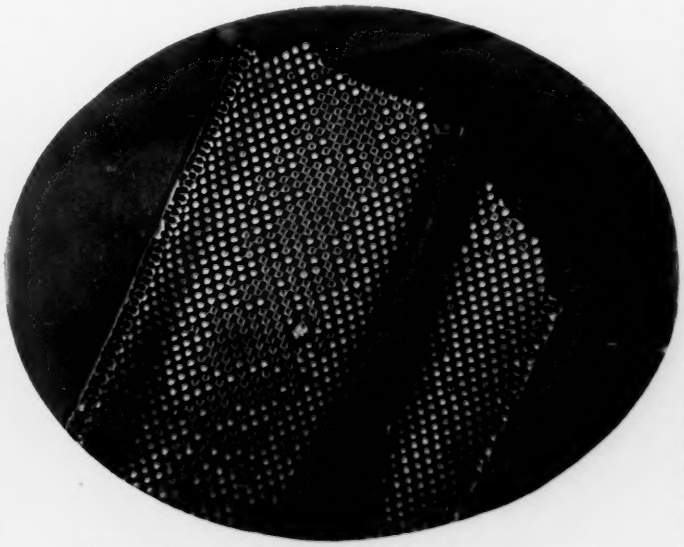

FIGURE 14. The inner side of *Pleurosigma formosum* showing the fractures through the holes, the first ever seen under these conditions, × 1750.

Particular attention is also directed to this print, as it exhibits a structure of squares instead of the customary round beads. This is in accordance with the theory of Dr. Abbe, expressed in his paper on the relationship of aperture to power. He shows there that all the optical details of an object developed with insufficient aperture to resolve them properly, whether square, lozenge-shape, or triangular, are depicted either oval or round. Figure 4, from the same side, where the valve has not been acted upon, may seem to contradict this view. The present writer, however, has already given his opinion that these appearances do not denote structure, but are only a collection of focal

FIGURE 15. The inner side of *Pleurosigma formosum* where the valve has been acted upon in parts, leaving bare the fibrils or grating, × 1750.

images thrown from the other side of the valve, as on a screen. The structure does not seem to differ much in character from that of the outside, except in being more robust. See Figure 15 for this, taken also from the inner side.

Comparing the optical results from the same diatom, in the photographs taken both by the oil immersion and the dry lens, is there any reason for doubting the utter futility of attempting to elucidate further the structure of *P. formosum* with an objective of only 1·0 N.A.? Yet the *Transactions of the Royal Microscopical Society* show that this feat has been attempted by one of its Fellows within the last two or three years. The chief, the almost sole, advantage of the oil immersion apochromatic lens is that by its refinements of correction it can stand more light, and have more of the available aperture utilised. The almost possible limit of resolving power was reached by the old glasses with an aperture pushed to 1·50. It was proposed to carry resolution still further by an objective of only 1·0, with a top-stop as an accessory. The results are recorded and figured in the *Transactions*—let the readers of "KNOWLEDGE" compare them.

When we come to *P. angulatum* we are dealing with structure of just double the fineness, where it is not so easy to get such striking examples of the torn structure to confirm the practical identity of the two. In *P. formosum* we can obtain it in long chains, as it were, here we shall find only links. Yet to those who know a chain when they see it, identical links should be sufficient for evidence. Indeed, from the various processes to which the valves are subjected it is only to be expected that the more fragile forms will get the most damage, and they do. The photographs of this species have been enlarged twice, for the better comparison; figure 16 shows the fragments of two valves, each with the opposite face outwards, forming a striking contrast. The torn structure seen just above the median line is from the *outer* side, and exhibits similar fibrils, with the same arrangement as in *P. formosum*—more especially seen at the left-hand bottom corner of the picture, where it is marked with a ×—exhibits the same focal images, projected from the other side of the valve. Above this again it will be seen that we get the normal appearance of the *outer* side when sound, and, in the uppermost division in strong contrast the characteristic hexagonal structure of the *inner* side. Figure 17 is another example from the outer side of still more torn structure; further, it is put here also to point a moral, if not to adorn a tale; for there is a tale.

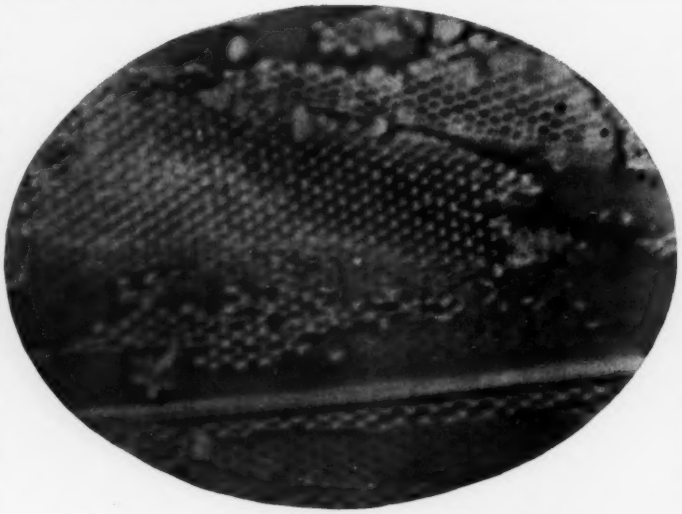

FIGURE 16. Fragments of the valve of *P. angulatum*, one showing the outer and one the inner side, × 3500.

Throughout the greater part of the period over which the history of the achromatic microscope extends, this species has been employed as a

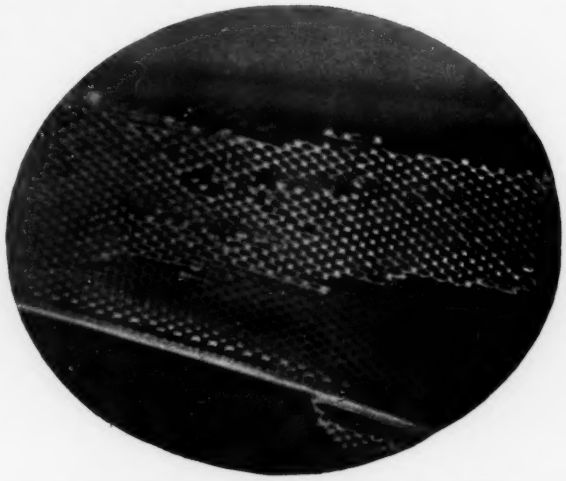

FIGURE 17. The outer side of the same, × 2500.

general test object, to illustrate different observers' theories. It has also been used to measure the advances, or the supposed advances, in the revealing of structure. Sometimes it has served as a proof that it can offer no evidence of the real structure at all—Dr. Abbe to wit. In the September number of *Harper's Magazine*, for 1907, there is an article on photo-micrography with the ultra-violet rays, under which it is claimed that the resolving power of the microscope has been recently doubled. The customary *P. angulatum* is ushered in to make valid this claim. By an ingenious and, I am afraid, a somewhat disingenuous arrangement, two photo-micrographs of this diatom are placed side by side, one taken under the ordinary illumination and the other under the ultra-violet light, to prove it.

Now, somebody, somewhere, must have been taken in at the same time, for this supposed new structure was seen, and photographed, by the present writer twenty years previously. It had not then, and has not now, any special significance for him, except in illustrating his theory of focal images. Neither is it a severe test of the resolving power of the microscope; any oil immersion of 1·30 will suffice. The statement is from Germany, which produces some of the best micro-objectives in the world, and is also the home of some of the worst micrography.

FIGURE 18. The inner side of *P. angulatum*, × 3770, showing the isolated slip.

Of course, one does not wish to imply that the resolving power of the microscope cannot be increased, or even doubled, by the use of the ultra-violet light, only that the example given does not prove it. As far as memory serves, the method stated as being employed did not give much promise of future great discoveries. The object was not seen at all, surely fatal to accurate and refined definition. To know one's subject thoroughly it is necessary to work out the details under the microscope while sitting down, in order to recognise what to go for, before attaching it to the camera. More practical, the late Dr. Dallinger advocated increasing the resolving power by the judicious use of coloured screens. Yet, after experiments, he recognised that the objectives should be corrected throughout for any particular ray.

Now, turning to the inner side of the valve, enlarged as before, for better comparison, Figure 18 should give us the key to the much-discussed hexagonal structure. It offers, however, this characteristic difference from the corresponding side of *P. formosum*, that the fibrils or short bars of silex instead of being placed lengthways are set obliquely across the valve. It will be seen also that the zig-zag arrangement of the isolated strip, if joined to the broken edges bordering the clear spaces on each side, would require no crossbars to complete the so-called hexagons. Another peculiarity is that this seems to be real structure in which there are no focal images to obscure it. The analogy, in fact, would be more with the hexagonal middle structure of the large discoid and other forms.

There still remains the question of the intercostals, which Mr. E. M. Nelson maintains are the products of the second order of spectra only. If these are not real entities, then why are they produced from this one side of the valve alone? The structure on both sides is of equal fineness: given the same conditions of aperture and lighting, should there not be produced the same results? However, perhaps it is not well to express too pronounced an opinion on such a matter. We are dealing here with appearances so minute that six dots are arranged around one that once taxed the whole powers of the microscope to define.

Figure 19 is from a valve of *P. balticum*, still showing fibrils and also indications of the structure underneath. The appearances here have been put down to moisture in the dry mount; but, as it happened, Mr. E. M. Nelson exhibited the same diatom under the celebrated new objective of 1·63 N.A., presented to the Royal Microscopical Society by Zeiss. The object then was of a necessity mounted in a dense medium, yet in all respects it offered the same details as are figured here. So much for moisture in the mount. It will be seen that the fibrils differ to a certain extent from the preceding examples. They appear in this print as extended bars, with swellings at regular intervals, seemingly, when together, giving the semblance to beads or squares according to the aperture employed. This difference can be ascribed to one of two causes. It may arise from the true fashion of the structure in itself, or from imperfect resolution. Some countenance is given to this last view by referring back to Figure 11*, taken with the dry lens, where it will be seen the fibrils come out almost straight, though by no means so when under the wider aperture of an oil immersion. Every earnest student of Nature knows that often we arrive at a point where we stand groping helplessly outside the boundary of knowledge. We may hazard a guess as to the right way in; but there our efforts must end.

* See "KNOWLEDGE" for August, 1911, page 293.

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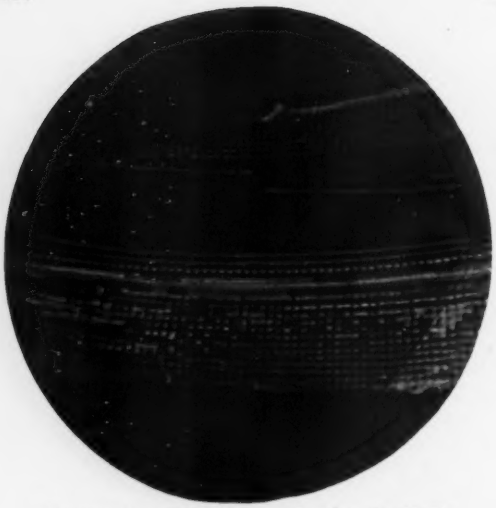

FIGURE 19. *P. balticum* showing the fibrils and the double structure of the valve, × 1750.

All the work figured here hitherto was done upon diatoms mounted dry. Later the writer was able to complete his evidence, of a unity of structure, upon other diatoms mounted in a medium. Figures 20 and 21 exhibit the same structure of fibrils upon a small *Coscinodiscus* so mounted, and being of sufficient thickness to allow the separate layers to be distinguished by an oil immersion. In one print the picture is much more crowded than appeared under the microscope, where the fine adjustment could be used. Only those who practice photo-micrography can appreciate the difference between seeing things in the microscope, and putting the same features vividly upon a plate. Visually the fibrils were unravelled, layer after layer, as one might unravel some woven material. Figure 21, taken at a slightly different level, shows two fibrils projecting into space, well separated from everything at the sides, above and below. Evidently the fibrils seen in the two prints, and not Mr. Slack's beads, form the sides of the hexagons of the middle layer of this diatom.

It is not assumed here that all diatom structure must be made up of similar fibrils. It is always dangerous to generalise from too little data. On the other hand the evidence is positive that much of the structure is, and there seems nothing to preclude the remainder from being formed of the same kinds of units. How these fibrils are deposited upon the true membrane of the lining vegetable cell is another matter.

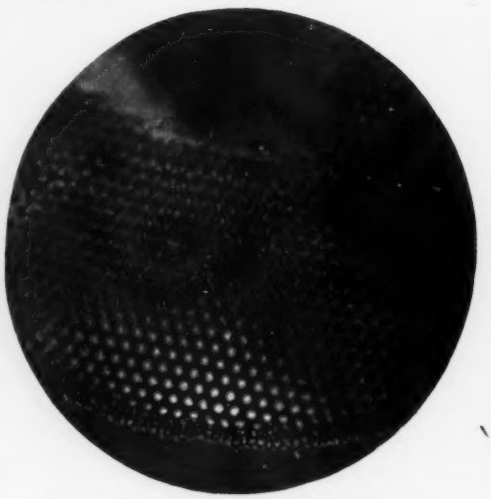

FIGURE 20. A small *Coscinodiscus* valve mounted in balsam, showing the same kind of fibrils forming the hexagons, × 1750.

This article would not be complete without reference to Dr. Henry Van Heurck's more recent work upon diatom structure, with the new apochromatic objective of 1·63 N.A. Plate 11 of the last edition of Carpenter was prepared by Dr. Van Heurck especially for that work. The description reads:—"This plate has a two-fold purpose. It is designed, first, to justify the opinions held by Dr. Van Heurck upon the structure of the valves of diatoms, and also to show how the usual microscopical tests present themselves when examined with the new objective . . . lately constructed by the firm of Zeiss."

The editor (Dr. Dallinger) thus describes Dr. Van Heurck's views. "He concludes that diatom valves consist of two membranes or thin films and an intermediate layer, the latter being pierced with openings. The outer membrane is delicate and may be easily destroyed by acids, friction, and the several processes of cleaning. When the openings or apertures of this interior portion are arranged in alternate rows, they assume the hexagonal form; when in straight rows then the openings are square or oblong."

Dr. Dallinger continues: "It is, however, due to Mr. T. F. Smith, who worked at this subject for years, to say that he long maintained this view. . . . . In Plate 1, Figure 1, we have a photograph of his, showing the *inside* of a valve of *P. angulatum* magnified one thousand seven hundred and fifty diameters, and exhibiting the "postage stamp" fracture; while in Figure 2,

FIGURE 21. The same taken at a little different level, × 1750.

in the same plate, we have the *outside* of *P. angulatum*, showing a different structure; and Mr. Smith has abundant evidence of the existence of what he has so long maintained.

"By using the new lens of the great aperture of 1·63, Dr. Van Heurck has produced some remarkable photo-micrographs, which rather confirm these general inferences than present any new data of knowledge concerning the diatoms."

As it happens, Figure 6 of the plate of Dr. Van Heurck shows an isolated strip almost identical with that given here in Figure 18, even to the breaking across in one particular spot. It should be interesting to compare the two, not only the strip, but also the edges of the fractured valve bordering the blank spaces on each side the strip. Figure 5, of the same plate, exhibits the hexagons magnified ten thousand diameters, which Sir (then Mr.) Frank Crisp, described, on its introduction to the Royal Microscopical Society, as a remarkable photo-micrograph. It proved subsequently to be only an enlargement from the original negative.

NOTE.—In the first part of the article, on page 289, Figures 1 and 2 were inadvertently interchanged, and on page 291, "720" should read 1720.

CORRESPONDENCE.

OBSERVATION OF URANUS AND VESTA.

To the Editors of "KNOWLEDGE."

SIRS,—Mr. Leonard speaks of Uranus being probably visible to the naked eye, and in this connection I may say that the planet is often distinctly visible without telescopic aid. Many years ago, while pursuing meteoric observation, it was my habit to obtain nightly glimpses of Uranus and I found it quite possible to trace, even with unaided vision, the displacement in the position of the object relatively to small stars near. In fact I considered it an attainable feat for the ancients to have discovered the planet with the unassisted eye had they watched the zodiacal stars with great diligence and compared exact positions. Indeed Vesta, as well as Uranus, might have been recognised in this manner.

W. F. DENNING.

THE DISTRIBUTION OF THE NIGHTINGALE.

To the Editors of "KNOWLEDGE."

SIRS,—As in the August "KNOWLEDGE" you invite observations on the distribution of the Nightingale, I take the liberty of sending the following:—

In the map given in "British Birds," it is shown as numerous, or fairly so, over the greater portion of this county. Now in the Devizes and Pewsey Vale district it is *extremely* rare. My father has been in this part of the county for thirty-five years, and the first instance of its occurring here he has heard of was on May 3rd, 1910, when one came to our garden and stayed for two days and a night (*i.e.*, it was on migration).

Round Salisbury and in South Wilts generally it is a common bird.

G. B. HONY.

THE TRUE STRUCTURE OF THE DIATOM VALVE.

To the Editors of "KNOWLEDGE."

SIRS,—With reference to Mr. T. F. Smith's article on the above, it would seem a word or two is needed. At the outset let me heartily congratulate him upon his most excellent photographs of the valve. From one or other of them absolutely the whole structure is laid bare, but what at the same time is truly astounding is the fact, that having this actually before him he needs misinterpret it and head off upon a "new structure discovery" ending up with "chains of fibrils formed of short bars of silex arranged lengthwise which run in pairs parallel, and each pair having larger and narrower interspaces between, in regular succession, and so on." All of which is totally beside the mark and quite misleading to amateur microscopists.

These "chains of fibrils" in *Pleurosigma*, as well as Mr. Smith's "pins" in *Podura* scales, are as spurious to the true structure as the Man in the Moon. One is aware that kaleidoscopically they may be observed and even photographed, but taking his own example of sheets of transparent paper with markings thereon placed behind one another, although he has separated the sheets, in one photograph or the other, he ends with placing three together (at least) under a peculiar illumination and gives this as the true structure. It is disappointing that with such excellent photographs the time and patience should be expended in finally misreading their purport and sallying forth into print to further mislead mayhap other amateur microscopists. As I have only seen the first portion of Mr. Smith's article published, I am anxious to see what further discoveries he has in store for us.

F. J. W. PLASKITT.

SIRS,—By your courtesy I have received a proof of Mr. F. J. W. Plaskitt's letter printed above, which gives me the opportunity of replying, without the delay of another month. For his kind reference to the excellence of my photographs I thank him, at the same time taking exception to his strictures on some of my work. He says, for instance: These "chains of fibrils" in *Pleurosigma*, as well as Mr. Smith's "pins" in *Podura* scales, are as spurious to the true structure as the "Man in the Moon." By "spurious," I suppose he means due to diffraction effects. If so, why do they leave off in certain places, while at the same time there is an extended structure immediately underneath? Not only that, the structure I exhibit is irregular, while diffraction effects are not. Diffraction effects result also from a narrow cone of illumination, while I always work with a wide one of strictly central light.

Mr. Plaskitt says that in one or other of my photographs: "absolutely the whole structure is laid bare"—then—"but what at the same time is truly astonishing is the fact, that having this actually before him he needs misinterpret it and head off upon a new structure discovery" and so on. Further: "He ends with placing three together (at least)"—does Mr. Plaskitt mean three layers of structure, or three photographs?—"under a peculiar illumination and gives this as the true structure."

Unfortunately he does not give the numbers of the figures to be praised, and otherwise, for guidance, leaving me quite in the dark as to the work for which I am to be blessed and for which to be banned. As the other part of my article appears in this number of "KNOWLEDGE," I suppose he will now have further exceptions to take; will Mr. Plaskitt kindly supply the references I ask for, when I shall be pleased to do my best towards meeting his points. I have never run away from a discussion yet, but I naturally want to know what I am fighting.

T. F. SMITH.

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MOUNTAIN BUILDING AND ORE DEPOSITION.

By J. E. W. RHODES, Assoc. Inst. M.E.

Of all physical features, mountains are among the most familiar but yet the least known. Few are ignorant of the romantic legends that cluster round them, of the poets who have sung of them, of the nations who have defended them; and to the student of History they have ever had a fascination,

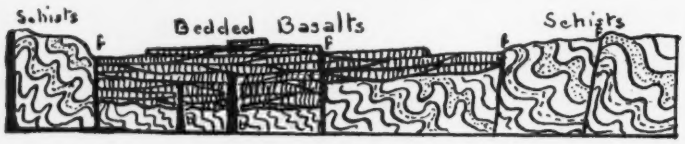

Figure 1.

as the walls that have kept race from race, and sometimes guided the destinies of nations. Again, in the hard world of to-day they are still there, the natural frontiers of the soldier, and the only partly subdued obstacles of the engineer. Yet after all this is only a superficial view—they are something more than view points, and if we enquire into their structure we shall find that every crag has its meaning in the long story that is now revealed to us.

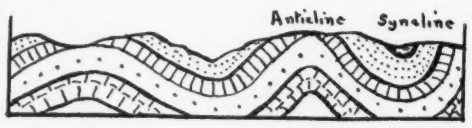

Figure 2.

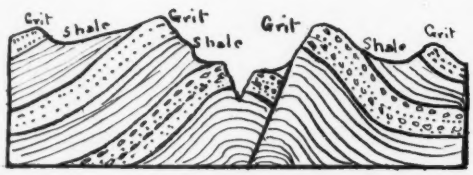

Figure 3.

The first characteristic of a mountain that we notice is its height above its surroundings, not merely height, but relative height. An upland plateau is not a mountain, however high it be, but all the characteristics of a true mountain range may be shewn by a low ridge. Thus the Malverns rise to little more than one thousand feet, yet in structure they are true mountains. Of almost equal importance is ruggedness, which is intimately associated with the first characteristic; for it expresses the steepness of the mountain, that is to say, the height divided by the horizontal extent.

Let us analyse these facts. Elevation requires upheaval, and so a mountain chain must have been at some time upheaved. Impressed by this truth the earlier observers neglected all others and attributed not merely the height but even the details of the form of the mountain to this cause. Von Buch, for instance, easily explained the perched blocks of the Alps in this way. When the mountain chain was thrown up, the motion was so violent that rocks were detached, and thrown up into the air, subsequently coming to rest on the sides of the mountain.

But detailed study soon shewed that things were not so simple. No violent catastrophe ever threw up a completed mountain chain and left it perfect. The moulding of its form was the work of ages and of more than one cause. And its complicated topography is but the expression of its no more simple architecture. Its hard and enduring rocks have been bent, broken, and contorted by great earth movements ere the long course of denudation sculptured its present form.

So the primary origin of mountains is in movements of the earth's crust, and it becomes of importance to us to know in what ways the earth's crust can move, and what effects each kind of movement may have. Earth movements are of two kinds, viz.,

Figure 4.

1. Vertical, up-and-down, or plateau building.
2. Horizontal, tangential, or mountain building.

The plateau building movements are the result of the sinking or rising of one area relatively to another. They take place owing to the weight of the strata which tend to sink in blocks into the still fluid portion of the earth's interior, which, being molten, is probably lighter than it, and gives rise to more or less vertical faults or dislocations which bound the blocks. Thus the great basaltic plateaux of the Western Isles of Scotland have been let down by

great faults between much more ancient rocks. In the deep fissures and cracks produced by this motion huge floods of basaltic lava have welled up while the sinking blocks of the crust sank into their place. The type of structure thus produced is shown in Figure 1.

The mountain-building movements are probably caused by the gradual contraction of the earth as it cools in the long course of ages. The molten interior contracts faster than the solid crust, which is kept at a more constant temperature on account of radiation, atmospheric circulation, and the heat received from the sun. From time to time, to be strictly accurate, at all times, the outer crust is being drawn inwards by gravity. One effect of this tendency has already been noticed, viz., the vertical movement is to originate a series of folds such as are shown in Figure 2, dipping in the direction of the movement and striking across the country, in a direction at right angles to it. As the movement intensifies the limbs of the folds become steeper and steeper, the more brittle strata snap at the crests of the folds as in the great anticlinal fault which marks the Pennine Chain in Lancashire and Yorkshire (see Figure 3). At last the folds themselves become folded, that is to say, their axes bend over and isoclinal folds are produced in which both limbs dip in the same direction, and the whole system of folds and faults is arched and crumpled up, as shown in Figure 4. In this intense crushing the limbs of folds are often so compressed as to squeeze the core of the fold

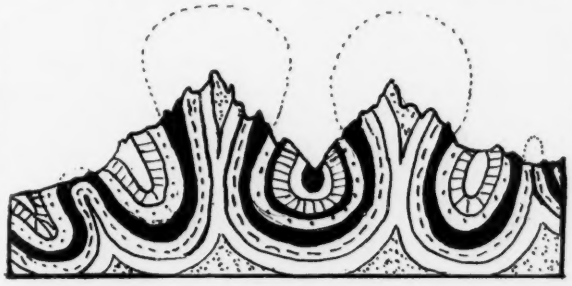

FIGURE 5.

FIGURE 6.

slipping downwards of some areas of the earth's crust relatively to others, or plateau formation. But since a small sphere has necessarily a smaller area than a larger one, it follows that the bodily sinking of one portion of the earth's crust squeezes together other parts, and this movement or pushing aside of parts of the crust is horizontal or tangential. The pressure of this movement is so enormous and irresistible that the solid rocks of the crust are folded, crumpled, and piled on top of each other in their endeavour to occupy a less horizontal space. It is to the piled-up masses of strata raised in this way that we properly give the names of mountains, and the detailed study of the way in which their component beds have moved is of peculiar interest.

The effects produced vary according to the nature of the strata. Igneous rocks and quartzites are very brittle and have a great tendency to break when folded, but soft shales can be very highly crumpled without fractures. With the less brittle rocks the first effect of a horizontal earth bodily into the crest giving rise to fan structure (see Figure 5), and the component grains of the rocks themselves are broken and drawn into parallelism with the strike of the folds.

FIGURE 7.

The extreme brittleness of many rocks gives rise to another set of features, and since both brittle and more or less flexible rocks are usually found close together these effects are usually added. According to the recent researches of Mr. Cadell, it has been shewn that when horizontal pressure is applied to a brittle mass, the parts nearest the pressure instead of folding, break off and slide upwards on somewhat inclined planes. As the block slides up the pressure is brought to bear on the next portion of the mass and another fracture or, as it is termed, minor thrust, is produced. In this way a series of thrusts is formed dipping towards the applied pressure. At last the huge mass of strata piled up between the pressure and the undisturbed rocks is driven forward bodily along a gently-inclined plane till it rests on undisturbed rocks. The part overlying this plane often

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crumples up on account of the extreme friction, or is crushed into powder. This major thrust, as it is called, allows the movement to affect the hitherto undisturbed rocks below, which in their turn become thrust. This is illustrated in Figure 6 and Figure 7, the latter shewing how the most ancient rocks in the Scottish Highlands have yielded to these movements.

The chief earth movements that have affected great Britain and Western Europe may be gathered into four great periods :—

1. The Pre-Cambrian, which for our present purpose is unimportant and will not be dealt with.

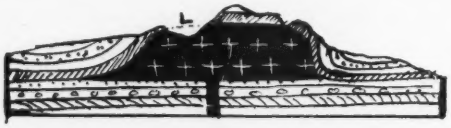


FIGURE 8.

2. The Post-Silurian or Caledonian, which folded the ancient rocks of North Wales, the Lake District, Southern Uplands and Highlands of Scotland, and whose folds generally strike W.S.W. to E.N.E., so that the movement must have come from the S.S.E.

3. The Post-Carboniferous, or Hercynian, which folded the Coal Measures and included two separate movements, one of which produced most marked effects in the South and the other in the North of England. The Armorican movement came from the South and crumpled the strata in the South and West of England into a range of mountains forming part of the great Armorican-Variscan chain, which then almost ranged across Europe. Though its effects are concealed from view in Eastern England by a mantle of newer rocks, it is well shewn in Devon, Cornwall and S. Wales.

The other Post-Carboniferous movement is called the Hercynian movement, and uplifted the Pennine Chain, forming great folds running North and South in the North of England.

4. The fourth great series of movements raised the chalk and converted it into land. These movements continued until the middle of the Tertiary period, and in Britain, especially in the Western Isles of Scotland, were of a plateau-building type. In Switzerland, however, great mountain building stresses were set up and resulted in the formation of the Alps.

It must not be imagined, however, that the highest peaks of any mountain range have received most uplift, and that the valleys necessarily lie in the troughs of the folds. Such is far from the case, for the uplift has always been so slow that the wasting action of air and water has had enormous effects, and the effects of the earth movements are only indirectly responsible for the scenery. The elevation of the Alps as a whole is due to earth movement; its individual peaks and valleys are due to the relative hardnesses of the diverse rocks of which they are composed.

In the study of mountain chains two things have long been noticed and as will now be seen have more than a practical interest. They are the abundance of mineral veins and of granitic and other igneous rocks. As has been mentioned before, igneous rocks also characterise plateaux, but they occur in a markedly different manner. If we examine the British metalliferous areas we shall find that they have all suffered from the mountain-building movements of the Caledonian and Hercynian, the great plateau regions of N.E. Ireland and the Western Isles of Scotland being devoid of mineral veins. It is also remarkable that most of the veins occupy fissures which appear to be due to the Hercynian and Armorican movements: only in a few parts do they appear to be Caledonian. To explain these phenomena it will be necessary to take a glance at the modern theories of the relationship of igneous rocks and mineral veins.

According to modern theories, beneath the solid crust of the earth lies a magma composed of fused rocks. Chemically it is composed, in the neighbourhood of the crust at any rate, of silicates and sulphides, which at the enormous temperature and pressure which there obtain are probably mixed together, although any lowering of temperature and pressure would cause them to separate into two layers.

The enormous pressure of the overlying rock tends to make this magma rise up through any cracks that may be present in the crust and dissolve large cavities in it. By so doing it draws nearer the surface and the sulphides and silicates separate into layers, the silicates at the top and the sulphides at the bottom. The fractures of the rocks caused by the great earth movements afford a ready means of escape, and in many cases the powerful uplifting

FIGURE 9.

action of the ascending rock has important effects. Thus a body of molten rock ascending a fissure may meet an impervious bed of rock and spread out as a sheet or sill, or arch up the strata to form a laccolite or occupy the core of a fold to form a phacolite. (See Figures 8 and 9.)

Since the silicate or rock-forming magma floats on the top we naturally expect that the formation of igneous rocks will precede the production of mineral veins, and when we come to examine the actual distribution of the ores we find that this is always the case. The tin veins of Cornwall are later than the granite, although certainly originally derived from the same magma, whilst the sulphide ores of copper in the same district are later still. In the same way the phosphate (apatite)) deposits of Norway represent the last stages in the consolida-

tion of the great masses of gabbro, and wherever the gabbro is pierced by the veins a very peculiar alteration is produced in the gabbro which shows that it has been affected by heated waters containing Chlorine, a characteristic constituent of the ore apatite.

We have thus traced mountain building, the formation of igneous rocks, and the production of mineral veins, back to the same source—the great crustal movements caused by the contraction of the cooling earth. Despite their enormous effects, these movements are so slow that they would escape notice altogether but for those surface symptoms, earthquakes and volcanoes, which remind us that there are jolts in the evenness of an otherwise imperceptible movement. Movements that have begun long before historical times are still unfinished. The Himalayas are even now being folded over towards the great plain of India, and the far more ancient Highlands of Scotland are still moving feebly along the old faults.

QUERIES.

Readers are invited to send in Questions and to answer the Queries which are printed here.

REPLIES.

46. BIBLE ASTRONOMY.—I do not know in what spirit J.W.A. has written this query. The sudden standing still of any of the heavenly bodies (apart from collision) is obviously of the nature of a *miracle*, *i.e.*, the operation of some special agency over and above the ordinary known forces. We clearly do not know its mode of action, so cannot introduce it into our mathematical analysis. But it would obviously be futile to leave out of account the action of this transcendent power, and yet to expect to obtain the true "effect on our planet and others of the system," on the assumption that only the known forces were acting. This is, however, the inconsistent assumption that J.W.A. appears to contemplate. Many think that the poetical and somewhat indefinite terms of the narrative can be sufficiently explained without assuming an actual change in the motions of the heavenly bodies. For example, he will find in Mr. E. W. Maunder's "The Astronomy of the Bible," the suggestion that the miracle was really the giving of unusual strength and endurance to the pursuing army, so that they made an afternoon march which would normally be deemed impossible, and inferred that the day had been lengthened.

A. C. D. CROMMELIN.

47. GRAVITY.—I think it is sufficient to simply say that it is gravity, and not the atmosphere, which prevents our falling off the earth.

A. C. D. CROMMELIN.

47. GRAVITY.—The statement made by your correspondent's friend, "That gravity is now rather discredited by scientific men" is quite incorrect.

The theory that "We do not tumble off the earth because it is surrounded by the atmosphere" is absurd on the face of it, seeing that the air, like every other substance, has weight and actually tends to buoy us up.

HUMPHREY WILSON.

QUESTIONS.

49. POLAR PHENOMENA.—I am thankful to the Rev. Mr. Davidson for enlightening me, in the February number of your journal, on some points of Polar Phenomena which had troubled me for some time past. May I take the liberty of troubling Mr. Davidson again, or any of your readers who may take interest in the matter, to enlighten me on the following points also.

1. An Indian author in his calendar for $86\frac{1}{2}°$ of latitude gives twenty-four to twenty-three days as the period of continuous long dawn, seventeen to eighteen days as the period of alternation of twilight and sun, and one hundred and sixty-nine to one hundred and seventy-one days as the period of continuous long day. Are these figures strictly correct, or may I assume that in actual observation they may vary slightly? I want a latitude which would give twenty-four days for the long dawn, sixteen days for the period of alternation and one hundred and seventy-one days for the long day. Will $86\frac{1}{2}°$ suffice for my purpose or shall I have to assume it to lie between $86\frac{1}{2}°$ and 87°—say, at $86\frac{3}{4}°$?

2. What is the exact manner in which the sun's disc is rendered visible during the sixteen days-long period of alternation? I am told that the period of alternation begins when the South declination is 4° 20′, and ends when the North declination is 4° 20′. Shall I be wrong in imagining that the phenomena of sunrise during the alternation period occur as follows? On the first day the sunshine will last for about one-and-a-half hours only, and the maximum portion of the sun's disc visible that day (at noon) will be about one-sixteenth of the whole. On the second day about a two-sixteenths portion of the disc will rise into view, and the day will last for nearly three hours. On the third day three-sixteenths, on the fourth four-sixteenths and so on, till at noon on the sixteenth day, the whole disc will have emerged into view, standing just above the line of the horizon. Of course, the stay of the sun above the horizon will not be in the *exact* arithmetical progression as I have stated above, but practically the progression may be assumed to be so, as the daily variation will be slight. I wish to know if the phenomena occur as assumed above, or whether the *complete disc* of the sun will be visible at noon, for some days during this period of sixteen days.

3. If the first day of this alternation period falls on the eighth day of the dark half of a certain month, will not the Vernal equinoctial colure occur on the new moon day following or on the first day of the bright half of the next month? And also, may not such colure be assumed to occur at the very beginnings of a new (lunar) constellation? A certain Vedic passage says that the new year's day falls on the eighth day of the dark half of the month connected with the constellation Maghā, which has been identified with Regulus (129°). Assuming this day to be the first day of the sixteen days-long alternation period, shall I be right in taking the equinoctial colure to occur in (Delta) Leonis (139° 58′)?

I shall thank any one of your readers if they will kindly enlighten me on the above-mentioned points.

BARODA. R.K.P.

50. RADIO-ACTIVITY.—Would any of your readers inform me concerning the following questions for which I have not been able as yet to find an answer.

(1) Is it definitely proved that the α particles of a radio-active body are helium? Is this transformation?

(2) What is the exact nature of X rays? are they identical with and the same as the γ rays of radio-active bodies?

(3) What is the cause of the glow of the glowworm?

H. SINCLAIR TAIT.

XUM

A NEW TABLE FOR PRACTICAL MICROSCOPY.

By THE REV. F. C. LAMBERT, M.A., F.R.P.S.

SOONER or later every user of a microscope experiences the inconvenience of the usual height (30 inches) of a writing table when it is required for a microscope with the tube in a vertical position. One feels the need either of a lower table, or an extra-

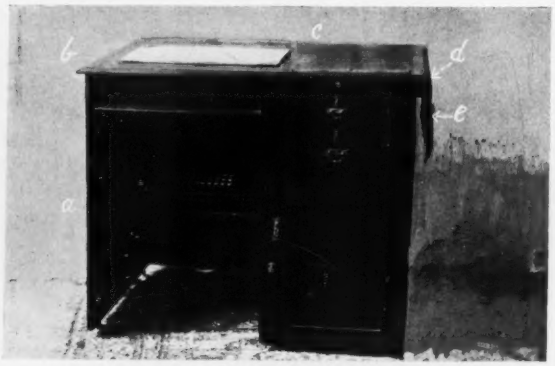


FIGURE 1.

high seated chair. To meet this difficulty, some time ago I designed a table and had it made by a local cabinet maker. One or two subsequent and trifling alterations have yielded me a perfectly satisfactory piece of furniture, which I propose to illustrate now somewhat fully, by means of photographs, so that any working carpenter should be able to repeat the apparatus in design, and modify its dimensions to suit the needs of his employer, by comparing the various illustrations one with another.

FIGURE 2.

The photographs had to be taken somewhat hurriedly in a quite small room, and with a hand camera without a swing back. These limitations will account for an obvious but slight distortion effect, which gives the table a tilted forward and enlarged top appearance. Some apologies are needed for the dust sheet background. Figure 1 shows a full face view of the table when in use for writing, and so on. Height from floor to top, including castors, thirty inches, length thirty-six inches, width twenty-four inches. The end flap shown hanging down on our right gives another eight inches length when it is raised on its side folding bracket. An ordinary half sheet blotting pad on the top gives one an idea of scale size. In the knee-hole part to the left is a shelf just wide enough to take a full-sized Smith-Premier typewriter which is here stored out of the way when not in use. Above this is apparently a handleless drawer, hereinafter explained. On our right is a knob by which one pulls out a flat slide which gives extra table room. Below this are two drawers, the upper, two and a quarter inches, the lower four and a half inches deep inside. The upper holds slips, dissecting tools and so on. The lower is nested with card divisions for bottles. Below, on the right, is a cupboard sixteen and a half inches high—amply tall enough to take any ordinary full-sized microscope case. At the back of this cupboard are two narrow shelves for sundries, larger bottles and so on. One of my difficulties was in obtaining sufficiently small and low castors, of which six are needed.

Figure 2 shows the end flap raised and draw slide partly pulled forward.

Figure 3 shows that the table top is cut and joined by "counter hinges." The left-hand part is folded flat over the right-hand portion of the table top. This folded-over part forms an excellent rest for bottles and sundries. To our left is seen a box-like recess.

In Figure 4 we see that the front side of this box-like arrangement has been removed and is laid on the table top. Behind one end is put a post card to act as background, and show the tongued end of this piece. We here also see the groove into which this tongued end slides.

In Figure 5 we see the microscope resting on the flat top above the typewriter shelf, four inches lower than the writing table top—*i.e.*, twenty-six inches from the

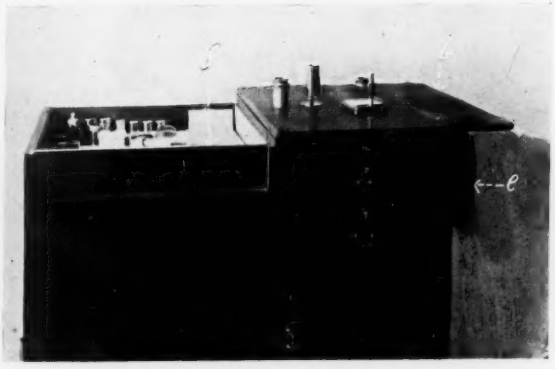


FIGURE 3.

ground. This I find quite high enough for vertical tube work. Indeed, perhaps twenty-five inches would be a more generally convenient height for an ordinary chair and sitter. This sliding part stows conveniently out of the way along the edge of the recess. The open cupboard shows the microscope case also out of one's way.

Before winding up, perhaps I may mention two very simple contrivances, which I have long used with great convenience.

Figure 6 shows a straight bit of wood about a foot long, two inches wide and one inch thick. In it are a number of circular holes large enough to take the immersion oil bottle, and a number of brass cases of objectives. A strip of card glued on the bottom of the wood prevents the things slipping about when it is moved. It is kept out of the way and yet conveniently at hand in the recess (Figure 3).

FIGURE 4.

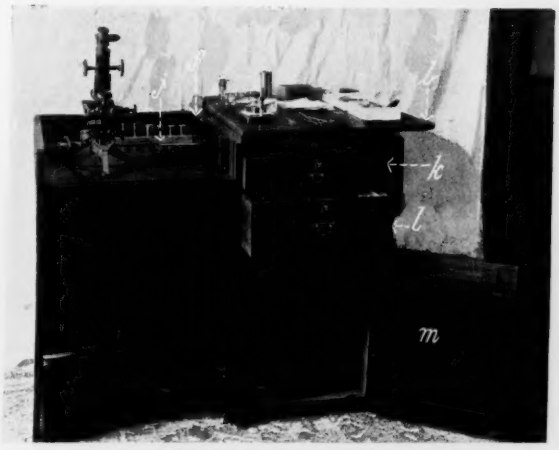


FIGURE 5.

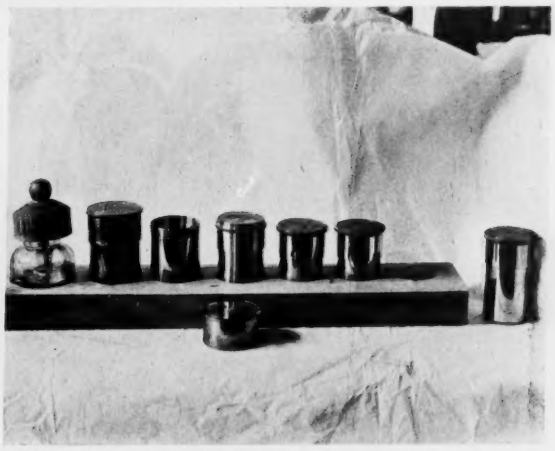


FIGURE 6.

Figure 7. A stiff card shallow box-lid in which are cut a number of nicks for holding tools and preventing them rolling about. Here are half-a-dozen special favourites:—

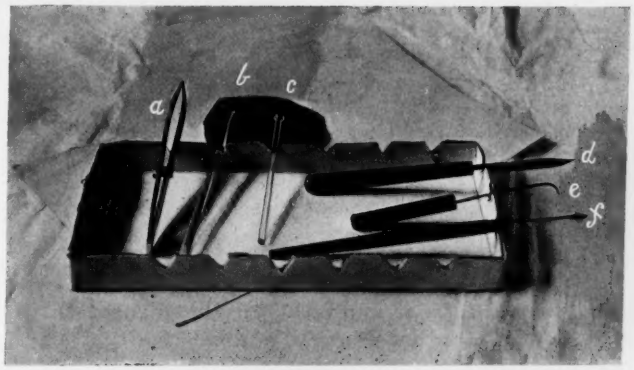


FIGURE 7.

(*a*) Forceps with slide clamp.
(*b*) Glass rod with drawn out slender point and tiny knob for applying reägents locally when dissecting.
(*c*) Another glass rod with knob end for applying a larger drop.
(*d*) A handled sharp-pointed knife.
(*e*) A *curved* needle for tearing out tissues.
(*f*) A double-edged spear knife.

To save repetition the parts in all the figures are uniformly lettered.

A Typewriter shelf.
B and C left and right hand portions of hinged top.
D Draw slide.
E Hinged flap supported by hinged side bracket.
F Sliding front of depressed table top.
G and H Tongue and groove of F
J Objective holder.
K Upper drawer.
L Lower drawer.
M Cupboard.

The lower level top arrangement on which the microscope rests (Figure 5), also serves admirably to hold my typewriter at a convenient height. The folded over part B (Figure 3) is then very convenient for writing, corrections, and so on. The back ends and door are all panelled; the back and ends have also styles (Figure 2). The work throughout is in solid oak and darkened by ammonia fuming. The carpenter's cost, not including castors, locks and keys, and brass handles, was four guineas. Doubtless, he would repeat at or about the same price. The workmanship is excellent. I send the carpenter's address to the Editor.

XUM

CLUSTERS AND NEBULAE.

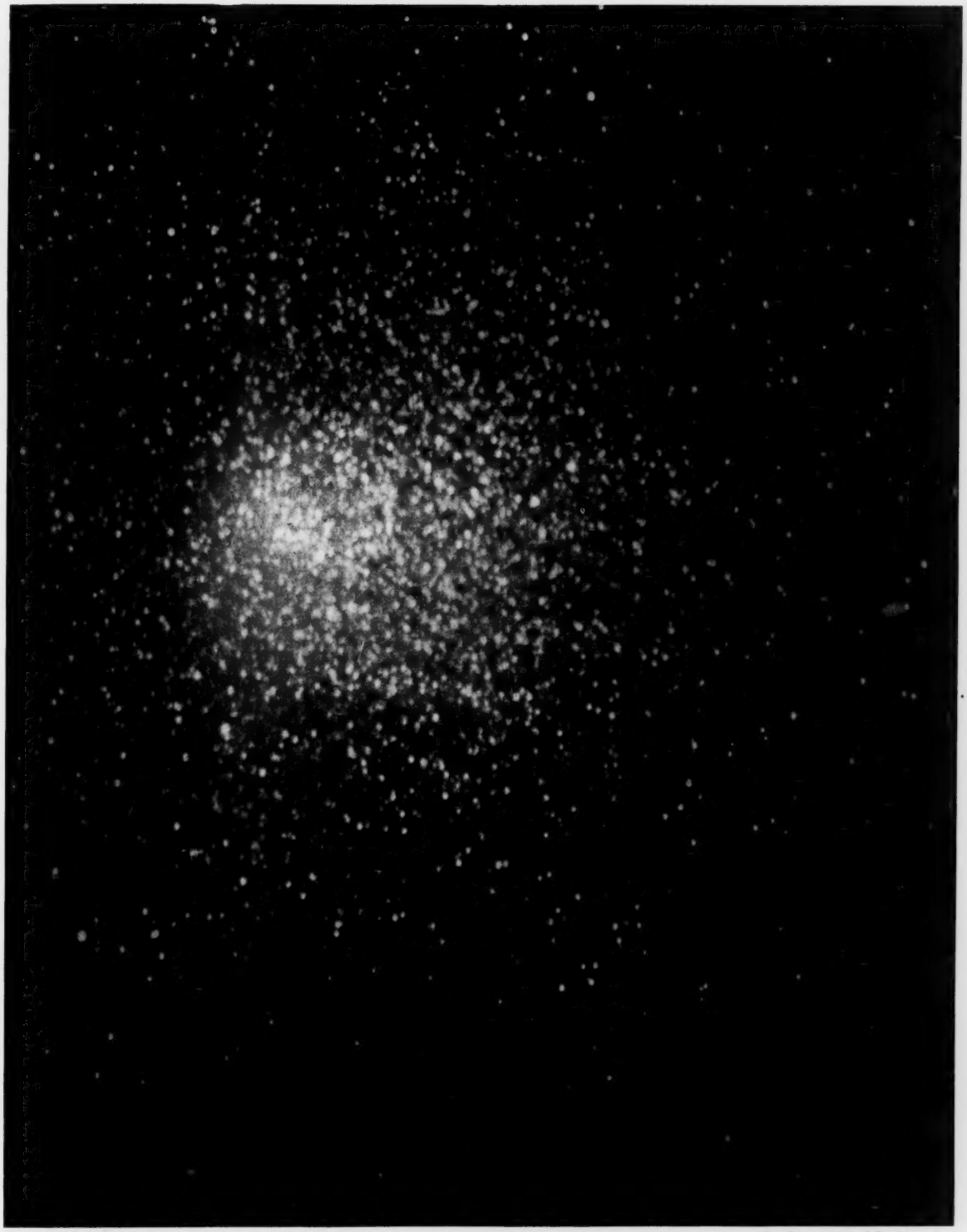
By F. W. HENKEL, B.A., F.R.A.S.

MORE than two thousand years ago the Greek philosophers, Democritus and Anaxagoras assured their countrymen that the luminous circle of the Milky Way consisted of nothing but dense masses of stars too small and too close together to be seen separately. The former, sometimes known as the "Laughing Philosopher" of Greece, also entertained some equally remarkable views on other subjects: the atomic theory, the nature of the sun and stars, and so on, many of which have been verified by later investigation. In addition to the Milky Way itself there are to be found, scattered all over the sky, luminous patches of cloud-like material, stellar groups or "nebulae," as some of them are called. Many of these are known to consist, like the Milky Way itself, of numbers of stars too near together to be separately visible to the unaided eye except in a few cases. The well-known Pleiades group in Taurus is an example. There are to be seen by the eye from seven to twelve stars close together, the number varying according to the keenness of sight of the observer and the state of the sky. With the help of the smallest telescope this number is increased to about one hundred, whilst the large telescopes and photographic appliances of modern astronomy have enabled us to detect the presence of a yet greater number of stars as well as streaks and wisps of nebulosity surrounding and enveloping most of the region. The Hyades cluster is situated close by in the sky, and not far off is the "Praesepe" in Cancer, which seen as a cloudy patch, becomes resolved into a swarm of stars, whence the name Praesepe (Beehive).

Other well-known clusters are those known as 13 M Herculis, not very far from the "apex" of the Sun's way, often considered the finest in the Northern Hemisphere, the cluster surrounding the star ω Centauri (see plate), the group in the "sword handle" of Perseus, the beautiful cluster M Canum Venaticorum (the Hunting Dogs), the cluster M 14 Ophiuchi, and so on. Some of these clusters are shown to be such by the help of very moderate telescopes, though they are better seen with larger instruments, others require more powerful optical aid, whilst yet others have never been resolved into stars, though on other grounds we have reasons for suspecting their "resolvability," as distinct from what are now known as "true" nebulae. Since, as we have said, most clusters, if visible at all to the unaided eye, appear to it as cloud-like misty objects or "nebulae," and are resolved into separate stars by a greater or less application of telescopic power, it was at one time thought that all such objects were of a similar nature, the difference between different clusters arising from the varying size of their members or their differing distances from our system. Whenever a new or more powerful telescope was applied numbers of these nebulae or cloud-like objects (Latin—*nubes*, a cloud) were "resolved" into separate stars, though some, such as the nebula of Orion and the great nebula of Andromeda, showed no signs of such resolvability. However, the great reflector of Lord Rosse being applied to the former, it was reported that this instrument had at last resolved the nebula, but this was a mistake, for as we shall see, no telescope ever can or will resolve it, since it is not composed of stars, but is of an entirely distinct and different nature. Fifty or sixty years ago, however, this idea of the resolvability of all nebulae into clusters was generally entertained. It was thought that they were remote clusters or "island universes," lying far beyond the system to which our own Sun belongs (the great Milky Way, or Galaxy), so inconceivably remote that light, though travelling at the enormous speed of over 186,000 miles per second, requires many thousands of years to reach us from them, and many may have ceased to exist ages ago, and yet it will be many ages hence before we become aware of their extinction. The work of Herschel and later investigators, showing the intimate connection between the distribution of the clusters and nebulae and the position of the Milky Way generally, has thrown doubt upon the validity of such views, though many popular writers have made these ideas generally known to the non-scientific public.

The memorable and systematic exploration of the heavens, with instruments constructed by himself and of far greater power than any previously used by astronomers, has immortalized the name of Sir William Herschel, and it is this, perhaps, more than the discovery of a new planet in the Solar system, which was his greatest contribution to our Science. Previously to his day the number of clusters and nebulae known did not exceed about one hundred and fifty or so, many of which were detected by the famous French astronomer Messier,* known as the "comet ferret" from his diligent search for those bodies, whose ill-defined and often misty appearance is not unlike that of a nebula, and indeed a comet has been not inaptly termed "a wandering nebula" for more than one reason. Sir John Herschel extended his father's work into the Southern hemisphere, staying for several years at Feldhausen, near Cape Town, and completely surveying the whole sky. In 1864, he published a catalogue of five thousand and seventy-nine nebulae and clusters, a great part of which had not been previously located by other observers. A supplement containing about a thousand more

* The letter M before the name of a nebula or cluster indicates that it is one which was included in Messier's catalogue.



From a Photograph by Curtis. *By the courtesy of Professor See.*

The Cluster ω Centauri.

of these objects was published by Dr. Dreyer after the death of Sir John Herschel, and additional lists containing objects discovered by photography and in other ways have, perhaps, brought up the number to double that contained in Herschel's catalogue. The most remarkable discovery in stellar, or perhaps we had better say sidereal, astronomy during the last half-century is that of the existence of *vast* numbers of spiral or "whirlpool" nebulae. Only a very few of these objects had been previously known, the first having been detected by Lord Rosse, about 1840, with the help of his great reflector, which showed the spiral form of the great nebula in Canum Venaticorum and others previously regarded as ring formed or annular.

Sir William Herschel divided these objects into—(1) Clusters of stars in which the stars are easily distinguishable; these are again subdivided into *globular* and irregular clusters. (2) Resolvable nebulae or such as excite the suspicion that they consist of stars, and which any increase of optical power may be expected to resolve into distinct stars. (3) Nebulae, properly so called, in which there is no appearance whatever of resolvability; these again were subdivided into subordinate classes according to their brightness and size, and so on. (4) Planetary Nebulae, (5) Stellar Nebulae, and (6) Nebulous stars.

Long previously to Herschel's day, Halley and other earlier discoverers of nebulae had followed the speculations of some philosophical writers in postulating the existence of a primitive elementary form of luminous sidereal matter, (Halley, *Philosophical Transactions*, Vol. XXIX, page 390, *et seq.*), but it was mainly as a result of his extensive observations that Sir William Herschel himself was led to consider the consequences of a gradual subsidence and condensation of such matter into more or less regular spherical or spheroidal forms denser towards the centre than at the circumference. Laplace's well-known nebular hypothesis, worked up by him from the previous suggestions of Kant, Wright, Swedenborg, and others, also brought into prominence this idea of "nebulous matter" of a nature distinct from ordinary solid or fluid substance such as we are familiar with on our planet.

The application of the spectroscope to Astronomy, about the year 1860, threw a flood of light upon subjects which had been thought to be beyond the power of the mind of man to discover, such as the chemical nature and physical condition of the heavenly bodies and enabled us to draw the real distinction between true nebulae and apparent nebulae, or remote and condensed clusters. Newton in his "Optics" relates that he once decided to "try the celebrated experiment of the colours." Admitting sunlight through a small opening into a darkened room, if allowed to fall normally on a white screen it produces a round white spot, which is an image of the sun. If now we introduce a prism or triangular piece of glass, with its edge downwards, in the path of the beam, the latter will be deflected upwards, and the image on the screen will be no longer white but coloured, a many hued band, showing the "colours of the rainbow." The prism, in fact, will have effected an analysis of the light. White light (sunlight) is composed of a mixture of different colours, and these on passing through the prism are deviated to a greater or less degree, the violet rays most *refracted* and the red least so. By employing a very narrow *slit* and a number of prisms (or a diffraction grating) a pure spectrum or coloured band of considerable length, in which the colours are well separated, is obtained. By such means Wollaston, and after him Frauenhofer, showed that the "spectrum" given by sunlight is not quite continuous, but crossed by a number of fine dark lines or vacant spaces. If the slit is illuminated by a gas flame or lamp such lines are not seen, but a continuous spectrum is obtained, giving the colours red, orange, yellow, green, blue (indigo) and violet, the so-called seven colours of the rainbow. Thus the dark lines are not characteristic of light in general, but only of sunlight. By special means it was shown that the brighter stars, too, gave spectra containing systems of dark lines somewhat similar to those given by sunlight, but with differences for different stars.

Passing over various stages in which the meaning of these lines, known universally as the Frauenhofer lines, was gradually unfolded, we come to the work of Kirchhoff and Bunsen. They showed that a continuous spectrum is given by every incandescent body whose molecules are so entangled as to be unable to vibrate freely; in other words, by solids, liquids and gases under high pressure. A gaseous substance, under low pressure, gives a discontinuous spectrum, containing only a few bright lines, and these lines are characteristic for each elementary substance, and also for some compounds. A gaseous substance, when cooler, absorbs from white light passing through it, precisely those rays which itself emits when hot. Thus the spectrum of white light, after passing through sodium vapour, exhibits two distinctive dark lines in the yellow, whilst *incandescent* sodium emits a yellow light, which, when examined by the spectroscope, is found to be of just that refrangibility. Thus it was discovered that somewhere between the Sun's luminous surface and the earth, there are a number of vapours of well-known elements, which form the "dark" Frauenhofer lines. Applying the spectroscope to the nebulae and clusters, a matter of some difficulty owing to the faintness of their light, the late Sir William Huggins, aptly named by Proctor the "Herschel of Spectroscopy," found that many of the former bodies gave spectra consisting of five or six bright lines, indicating the presence of hydrogen, magnesium, and nebulium (?) under low pressure, in a state of great rarefaction.

Some, such as the great nebula of Andromeda, give a continuous spectrum unmarked by lines or bands whether bright or dark. It is possible these may consist of more condensed gases, but this is by

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no means certain. Clusters and resolvable nebulae give spectra similar to those given by the stars showing their starlike nature, whilst the irresolvable nebulae, as we have just said, give either bright lines or continuous characterless spectra. Thus a real distinction of a physical nature may be drawn between the different classes of these objects. (Dr. Fath, however, is of opinion that, notwithstanding what has been just stated, "no spiral nebula has a really continuous spectrum," that the continuous spectrum of the Andromeda nebula, or at least that of its central portions, is given by "an unresolved star cluster consisting of stars mainly of the solar type.") Of late years photography has been successfully applied to spectroscopic purposes and spectrograms of many of the brighter stars and clusters, and nebulae, have been obtained. Amongst remarkable clusters and groups of stars with community of proper motion, which seem to be connected, in some as yet unknown way, by a force acting far more powerfully and at greater distances than gravitation, in addition to the Pleiades which we have already discussed (see also a paper by the present writer in "KNOWLEDGE" for July, 1907), may be mentioned the "five stars" in Ursa Major, which were pointed out by the late Mr. Proctor about forty years ago, as well as by Flammarion and others* and also the Taurus cluster investigated by Professor Lewis Boss. Drs. Ludendorff and Hertzsprung have shown that Sirius, the brightest star in our sky, is a member of a family which includes (besides the five stars, β, γ, δ, ϵ and ζ Ursae Majoris), also β Aurigae, 37 Ursae Majoris, δ Leonis and α Coronae Borealis. These ten stars appear to drift together, lying approximately in one plane and nearly in a right line. In the *Astronomical Journal*, Number 604, Professor Lewis Boss has discussed a moving cluster in Taurus, consisting of many of the Hyades. For more than twenty-five years he has been investigating their motions and found these "nearly identical," at least forty whose directions of motion converge towards a common though very distant point, "at which their apparent velocities will enable them to arrive almost simultaneously after the lapse of some sixty-five million years!" At present this "cluster" is spread over a total area of 15° but is somewhat condensed towards the centre.

It has been estimated that the average velocity of the entire cluster is about forty-six kilometres (say under thirty miles) per second, and the "average" parallax 0″·025 (Küstner) giving a corresponding distance from our system of eight hundred billions of miles, thirty times that of the nearest star, Alpha Centauri. As a result of Professor Boss's work in another direction, Mr. Eddington, of Greenwich, has given an account of a "Moving Cluster of Stars of the Orion Type in Perseus." Sixteen stars, lying between R.A. $3^h\ 11^m$ and $5^h\ 15^m$ Dec. $+42°$ to $+58°$, share very nearly the same motion, both as regards magnitude and direction, and thus form a group similar in character to those above mentioned. Their magnitudes range from 2·9 (ϵ Persei) to 6·4, and the mean "proper motion" is about 4″ per century.

On clusters of stars in general, and especially on the regular globular clusters it may not be without interest to notice the remarks of the late Sir John Herschel, who was the highest authority on such matters, and who had himself observed more of these objects than any other astronomer of his day. "We can hardly look upon such a group . . . as not forming a system of a peculiar and definite character. Their round figure clearly indicates the existence of some general bond of union in the nature of an attractive force; and in many of them there is an evident acceleration in the rate of condensation as we approach the centre, which is not referable to a merely uniform distribution of equi-distant stars through a globular space, but marks an intrinsic *density* in their state of aggregation, greater in the centre than at the surface of the mass." The stability of such a system "without a rotatory motion and centrifugal force," is scarcely conceivable, but if we suppose a globular space filled with equal, and very numerous stars, attracting one another according to the gravitation law, any one of these will be urged by a resultant force directed towards the centre of the sphere and proportional to its distance therefrom (law of direct distance, Newton). Under such a resultant force each individual star would describe a perfect ellipse about the centre of the system, no matter in what plane it might lie, or in what direction it might be moving. Thus it would not be necessary that the cluster should rotate as a mass around a single axis. Each ellipse described by the separate members would remain unchanged in form and dimensions, and all would be described in one common period, so that at the end of each such period every member of the system would be in exactly the same position with regard to every other, and would run the same round for an indefinite succession of ages. Such a system, whose members were sufficiently distant from one another so that their orbits did not intersect, might exist and realise a state of abstract and ideal harmony, transcending even the harmonious and stable conditions of our own Solar system, without any preponderating "Central Sun." However, it is probable that such a condition of affairs is but rare in the sidereal spaces; though many almost perfectly globular clusters are known, others are of a more or less oval outline, and yet others of irregular figure. These latter are also less definite in outline, so that it is not always easy to say where they terminate, and they are not often condensed towards a centre. By far the greater proportion are situated

* This community of proper motion was named by Proctor "stardrift." The stars appear not only to be moving together, but their chemical constitution as revealed by the spectroscope is similar.

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in or near the Milky Way, a fact which led Sir W. Herschel, quite early in his career, to infer the existence of a clustering power, akin to gravitation, which is gradually breaking up the Galaxy, and has already given that "great arch of light, the aspect of a series of clusters rather than that of a uniform band of milky light." Professor See, in his great work "Researches on the Evolution of Stellar Systems" (Vol. II.), has however, pointed out the important effect of the universally diffused cosmical dust, which acts everywhere as a resisting medium, so that "the Milky Way may have been always more or less aggregated into clusters, which have simply grown denser or become more dispersed with the flight of ages." If these clusters arose from the condensation of nebulous material, and this diffused "cosmical dust" acts everywhere, it follows necessarily that all clusters will, in course of time, become more dense and more nearly globular, unless the aggregations thus going on are dispersed by the action of external forces due to other clusters. Space will not permit our pursuing this interesting subject further, but it must be fairly evident that the study of the nature and conditions of formation, growth and decay of these objects is one of the grandest with which the human mind can be employed. We owe much to the patient labours of "self denying men of science" but more lies for the future to unravel, and as there appears to be neither end nor beginning to the Universe of God, so also must we believe that its complete comprehension will for ever transcend the finite mind of man.

SOLAR DISTURBANCES DURING JULY, 1911.

By FRANK C. DENNETT.

THERE has been a very slight increase in the amount of solar disturbance during July, but on four days (6th, 11th, 25th and 26th) no trace of activity was visible, bright nor dark, and on sixteen days (5th, 7th—10th, 17th—24th, 27th, 28th and 31st) only faculae could be seen. The longitude of the central meridian at noon on July 1st was 65° 41′.

No. 27.—When first seen on the afternoon of July 1st it was a single pore, but next day there were three forming a long triangle 25,000 miles in length. It was not seen on the 3rd, but a pore showed on the 4th.

No. 28.—A solitary spotlet only seen on the 2nd and 3rd.

No. 28a.—A group of four pores 23,000 miles in length, forming two pairs, only seen on the 4th.

No. 29.—Two spotlets, the western largest and accompanied by two pores, were visible on the 12th. During the next day considerable alteration took place in the group, by the afternoon the rear spot had enlarged considerably and thrown forward a sort of tail which broke into a line of small umbrae, having in front of them a small triangle of pores. On the 14th the rear spot was about 5,000 miles in diameter, with a curve of pores on the northern side and line of pores in front, having a total length of 52,000 miles. On the 15th its length was unchanged but its members were shrinking, and on the 16th only the hindermost spot was seen cut in halves by a bridge, with a tiny pore to the south. Not seen after, except its faculic remains near the western limb on the 19th, 20th and 21st.

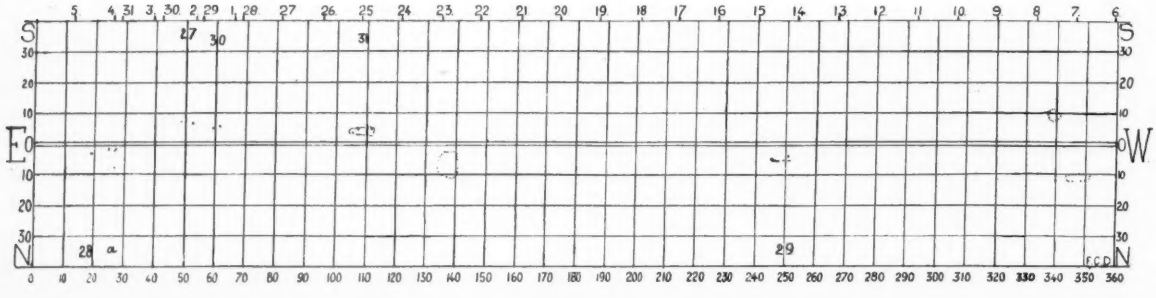
No. 30.—A group of three pores, one very tiny, 18,000 miles in length, on the afternoon of the 29th, but on the 30th only two minute pores seen close together, and not seen after.

No. 31.—A pore visible on the northern border of a bright faculic disturbance on the 30th, but not observed after.

On the afternoon of July 8th, a very pretty prominence eruption was witnessed, though on a very small scale. In adjusting the position circle of the spectroscope, a bright little bead was noticed only 3° west of the north pole. Within a very few minutes it threw up a fine needle of light which slightly expanded, then bent over polewards and began drifting off as clouds. The positions of the other prominences around the limb were measured, then on returning to the same point only a little bead of light remained. The position of the bead was measured at 5.45 p.m., and the observation was completed at 6.10, so that the eruption could only have occupied a few minutes.

Our chart is constructed from the combined observations of Messrs. John McHarg, E. E. Peacock, and F. C. Dennett.

DAY OF JULY, 1911.



NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

Being at the seaside and away from all sources of astronomical information or reference my notes this month are very brief.

ENCKE'S COMET was found on the last day of July, by M. Gonnessiat, at Algiers. Owing to its unfavourable position there were some apprehensions that it might escape detection at this return, and thereby break a remarkable record of visibility at every return since 1819. Perihelion is passed about August 20th. After the observations of this return have been discussed, it will be possible to discriminate between Professor Backlund's two hypotheses to explain its recent movements, viz.: (1) that it suffered a sudden change in its rate of acceleration about 1905, (2) that the mass of Mercury which he had previously derived is sensibly in error. Encke's comet affords the best way of determining the mass of Mercury, since the two bodies are periodically very near together. None of the planets are sufficiently perturbed by Mercury to give its mass with any accuracy.

BROOKS' COMET.—After last month's notes were written, the veteran comet discoverer, Mr. W. Brooks, of Geneva, U.S.A., discovered a faint comet, which is likely to brighten into naked eye visibility before next November, when it makes a fairly near approach to the earth. The earth, about September 3rd, will pass through the point occupied by Kiess' comet four weeks earlier. There is a possibility of a meteor shower at that date, if the comet has a meteoric appendage following in its wake, as some comets are known to have.

SOLUTIONS TO MR. BARTRUM'S QUERIES (page 311).—The answer to the first query, *re* the illumination of Venus, is that his law of illumination, varying as the cosine of the angle of incidence, only holds for smooth spheres, which the planets are not. Even tiny inequalities on the surface, far too small to be discerned from other planets, suffice to give an altogether different law of illumination.

The most casual glance at the Moon suffices to show that the illumination at the terminator is very different from zero, which it would be on his hypothesis. The actual law is doubtless a very complicated one, but empirical formulae have been given for representing observed facts with fair approximation. The formula used in the *Nautical Almanac* for finding when Venus is brightest is avowedly only a rough approximation, and does not profess to accurately represent the facts of nature. It is only used because the phenomenon is not considered a sufficiently important one to call for a refined investigation; indeed it would be practically impossible to determine by observation the average slope of the small inequalities on its surface, which would be one of the necessary data of an accurate solution. *Re* his second query, the phrase "mean distance," if used without further qualification, is always taken to mean the semi-major axis of the elliptical orbit. If any one desires to use the phrase in one of the other meanings which he indicates, it is necessary to specially state the fact.

I prefer to postpone his third query till next month. I think I see the fallacy involved, but it is easy to make mistakes in such problems. In any case, he has succeeded in finding a neat little astronomical catch.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

PRE-GLACIAL FLORA OF BRITAIN.—In a recent paper on the plant remains found in the Pre-glacial deposits of Norfolk and Suffolk, Clement Reid (*Journ. Linn. Soc.*) gives a list, with notes, of the Pre-glacial species of British flowering plants now known, numbering one hundred and fifty. The plants described grew in the small stream channels of a large river, probably the Rhine, and in the adjoining wet meadows or in moist woods close at hand. The flora of Norfolk and Suffolk as a whole has altered very little in the many thousands of years since these beds were formed, although it was driven out by the cold of the Glacial Period and returned later. A certain number of exotic species are recorded, however, these including three species of *Ranunculus*, a water lily, the water-nut (*Trapa natans*), the spruce fir (*Picea excelsa*), and *Naias minor*. The southern element in the Cromer flora is therefore greater than was formerly supposed, and it apparently includes several extinct species. These pre-glacial plants suggest climatic conditions almost identical with those now existing, but slightly warmer—a difference doubtless owing to the fact that Britain was then united with the Continent.

THE FUNCTIONS OF LATEX.—In a very large number of flowering plants, there are special sacs and tubes containing the juice called latex, which is commonly milk-like in appearance (*e.g.* in dandelion, spurge, sow-thistle), but may be colourless, or red, or orange in colour. Latex contains a great variety of substances (*e.g.* proteins, starch, rubber, alkaloids), and its uses to the plant have been much discussed. Some writers state that latex is mainly, if not entirely, composed of waste substances, which do not enter again into the metabolism of the plant, though useful in guarding against the attacks of animals, on account of the bitter and poisonous substances they contain. Others contend that latex is largely made up of reserve food materials, which are eventually used up in the nutrition of the plant.

The most recent contribution to the controversy is a paper by Bernard (*Annales du jard. bot. de Buitenzorg*, 1910), in which some interesting new facts are given. This writer supports the view that latex functions largely as a depository of reserve food materials. He finds that the fruits of various latex-containing and rubber-yielding plants have abundant thick latex when young, whereas the ripe fruits contain very scanty and thin latex. This he regards as proof that the substances present in latex are used up in the formation of the fruits and seeds, after being converted into other food materials. He also shows that when spurges are cultivated in air deprived of carbon dioxide, so that they cannot manufacture carbohydrate foods from external sources, the starch grains in the latex are corroded and are apparently changed into sugar for the nutrition of the plant.

ACIDITY OF BOGS.—As is well known, the peat-moss (*Sphagnum*) rarely grows on limestone soils. Some years ago, it was shown by Paul that calcium carbonate is very injurious to *Sphagnum*, even in small quantities. He grew various species in water containing lime and found that the plants soon perished. He found that not all salts of lime have an equally injurious effect, and that alkaline salts of potassium and sodium are as deleterious as those of lime. Various other writers have found that peat-mosses give an acid reaction; hence it has been suggested that the injurious effects of lime

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may be due to the neutralising of the acidity of the moss; that forms growing on high moors contain more acid than those found on low heaths, and that the former are more sensitive to lime; that on high moors there is less mineral food available for the Sphagna in the substratum, and that the amount of acidity and the sensitiveness to its neutralisation decrease as the amount of available mineral food increases; also that high moor Sphagna usually absorb more water than those growing on low heaths.

Baumann and Gully (*Mitt. d. K. Bayr. Moorkultursnatalt*, 1910) have confirmed Paul's statement that living *Sphagnum* plants give the same free acid reaction as does peat derived from the dead remains of *Sphagnum*. They also show that living or dried *Sphagnum* plants dissolve calcium phosphate in the same way as peat. From numerous experiments, they conclude that the acidity of peat and of *Sphagnum* is due to the presence of colloidal substances of acid character in the cell-walls.

Czapek showed, some years ago, that *Sphagnum* contains various interesting chemical substances. One of these, "sphagnol," is injurious to Bacteria and thus acts as an antiseptic, preserving the dead *Sphagnum* tissue from destruction and helping in the formation of peat. The walls of the clear water-holding cells of the leaves also yield on treatment with alkali large quantities of jelly-like substance, probably identical with Baumann's "*Sphagnum* colloids."

SENSITIVE STIGMAS.—As is well known, the flowers of various species of *Mimulus* (monkey-flower, musk) have a stigma with two flat diverging lobes, which when irritated shut together so that one stigmatic (inner) surface meets and presses against the other. The inner surface is the sensitive part, a touch on the outside of the lobes producing no effect. The closing movement is instantaneous; after from five to eight minutes the lobes begin to diverge again, and in ten to fifteen minutes have regained the position of rest.

These movements, which occur in some other plants, *e.g.* species of *Torenia* and *Martynia*, were first described about a century ago, but the only detailed account, until quite recently, was that given in 1902 by Bruk. According to Bruk, in *Mimulus* the lobes remain closed only if the stimulus has been caused by placing on them specific pollen (*i.e.*, pollen from the same flower or from a flower of the same species), and soon open and remain open if foreign pollen (*i.e.* pollen from a different species of plant) is used. He also stated that in *Torenia fournieri* the lobes will open again and remain open if pollen from the two shorter stamens of the same flower has been placed on them; this point is referred to below.

Oliver, in 1887, showed that the stimulus is transmitted from one lobe to the other; if one lobe is prevented from moving (*e.g.* by cementing it to the corolla), a touch on its inner face still provokes movement in the other lobe. He also showed that the transmission takes place through the ground tissue of the lobes, probably by means of intercellular protoplasmic connexions, since transmission occurs when the vascular bundle is cut through.

Lutz has made a thorough investigation of irritable stigmas (*Zeitschrift für Botanik*, 1911). The ground tissue of each stigma lobe is sharply divided into two zones, the inner zone forming the conducting tissue (down which the pollen tubes pass) and the outer consisting of compact parenchyma; the epidermis of the outer side is strongly cutinised and has no papillae, that of the inner side has very thin cuticle and is produced into long hairs which receive the stimulus of contact. The movement of the lobes is brought about by a sudden lowering of the osmotic pressure, and diminution in volume of the whole ground tissue. The diminution in volume is not uniform, but very different on opposite faces of the stigma lobes, being in fact about twice as great on the inner face as on the outer face. By artificially withdrawing water by osmosis there can be produced a closing together of the lobes similar to that resulting from stimulation.

Lutz carefully investigated the results of pollinating the stigma of *Mimulus cardinalis*, and so on, with pollen of the same species and also with foreign pollen. He tried the effect of placing pollen in different quantities on the inner surface of the stigma lobes—on one small area, on about half of the inner surface, on the entire inner surface. If little pollen is used, whether of the same species or not, the lobes at once close, then open again in about ten minutes. With more pollen, enough to cover about half the inner face of the stigma lobe, the lobes open again after about ten minutes; but if the pollen used is of the same species, a second closing movement begins after from two to three hours and lasts for about twenty minutes. If, however, the pollen is carefully placed on the stigma to avoid mechanical shock, the second closing movement occurs as usual after between two and three hours, although the first (contact irritability) movement is not made. When a large amount of pollen is used, the whole inner face of the stigma being covered, the first instantaneous movement occurs as usual, owing to the mechanical shock stimulus in applying the pollen, but the lobes remain closed, never diverging again. If the stigma is loaded with foreign pollen, it closes at once as usual, and remains closed for two or three hours, but then opens again.

In these interesting experiments with small, medium, and large quantities of pollen, Lutz worked chiefly with *Mimulus cardinalis*, and used in each case (1) pollen from long stamens of same species, (2) pollen from short stamens of same species, and (3) pollen from various foreign species—Snapdragon, Plantain, and others. His results show that the permanent closure or the reopening of the stigma lobes is determined in the first instance by the *quantity* of the pollen applied—a large quantity causes permanent closure, a smaller quantity does not; and, secondly, by the *origin* of the pollen used—a full load of pollen of the same species results in prolonged closure, foreign pollen in closure for a few hours at most. In opposition to Bruk's results, Lutz finds that in *Torenia* the anthers of the short stamens dehisce later than those of the long stamens; that pollen from undehisced anthers is not capable of germinating; and that when such pollen is placed on the stigma, the latter opens in ten to fifteen minutes after the usual closure.

Lutz proceeds to analyse the two closing movements which result on the placing of suitable pollen on the stigma. The instantaneous first movement is purely the result of the mechanical stimulus. Bruk explained the permanent closing of a pollinated stigma as being due in part to the pollen grains abstracting water from the stigma tissue, and thus preventing this tissue from returning to its original state of turgescence. This explanation is supported by the observation of Lutz that the stigma only remains closed when a large amount of pollen has been placed on it. Lutz also noted that sometimes, even with a full load of pollen, the stigma lobes after from one to three hours opened again, doubtless recovering turgescence by being supplied with water from the ovary and style—but this re-opening would not, of course, interfere with fertilisation, since the pollen had had ample time to germinate and send the pollen-tubes into the conducting tissue.

Lutz found that not only specific and foreign pollen, but also such substances as dry sand and powdered starch could cause prolonged closure of the stigma lobes. On the other hand, wet pollen caused only temporary closure (for ten to fifteen minutes); only *dry* pollen could produce prolonged closure. The permanent closure, resulting simply from the prevention of the automatic re-opening movement, is due to (1) the absorption of water by the pollen grains and their germinating tubes, and (2) the chemical effects of the growing pollen-tubes on the conducting tissue of the stigma lobes. If either of these conditions be absent, the stigma lobes open again after a shorter or longer time. Both conditions are fulfilled by the germination on the stigma of the pollen of the same species. This portion of Lutz's results may be summarised by stating that the stigma remains closed only if the pollen grains and the germinating pollen-tubes can, by abstraction of water, prevent the return of the original osmotic pressure in the stigmatic tissue, and the consequent reversal

of the primary closing movement, until a sufficient number of pollen-tubes have penetrated the conducting tissue and so disorganised it that re-opening of the lobes is made impossible.

The next question is, *how* do the entering pollen-tubes cause this remarkable disorganisation of the stigmatic tissue? The entering tubes will resorb the very thin cuticle between the stigmatic papillae, and they will, after some time, absorb sufficient water to prevent a return to the original turgescence in the stigmatic tissue, but the disorganisation of the stigma is not entirely explained in this way. Evidently some chemical substance or substances contained in the pollen grains and tubes must diffuse into the conducting tissue, and there cause disorganisation of the cells. Lutz tried the effect of watery extracts of the pollen-grains. On placing a drop of this extract on the stigma, the latter closed as the result of the mechanical stimulus, and remained closed, also showing, after a few minutes, a yellow discoloration, while the microscope showed exactly the same kind of disorganisation of the conducting tissue as is caused by the pollen tubes. The extract did not act as a chemical closing stimulus on the stigma, however. On putting a stigma into the extract it began to close gradually after a few seconds, whether the stigma were irritable or not; this closing occurred in insensitive stigmas—old stigmas, and stigmas made insensible by treatment with ether, for instance. That is, the closing movement was due to chemical *action* of the extract, but not to a chemical *stimulus*; the extract injured the stigma cells but did not act as a stimulus to movement. Beyond ascertaining that the active substances extracted from the pollen were not destroyed by heating to 100°C., Lutz made no attempt to isolate and identify them, because exactly the same result was brought about by extract of pollen of all kinds of other plants, and by solutions of various organic and inorganic substances.

Clearly, then, the permanent closure of the stigma lobes in *Mimulus* and so on, is brought about by abundant pollination with pollen of the same species, while with foreign pollen (the tubes of which either do not penetrate the stigma or only do so occasionally and imperfectly) the stigmas open again after a time. When killed pollen-grains of the same species are applied to the stigma, the latter opens again in an hour or so; the dead pollen can absorb water from the stigma tissue, and of course it still contains the chemical substances which injure the stigma tissue, but it cannot produce pollen-tubes which are required to conduct the chemical agent to the conducting tissue.

Of what advantage to the plant are the movements of the stigma-lobes? Bruk's answer was that the closing up of the stigma-lobes is a protection against the germination of foreign pollen. Lutz finds, however, that the pollen of some foreign plants germinates almost as well on the stigmas of *Mimulus* and so on, as the plant's own pollen, though the foreign grains do not seem able to send their tubes into the conducting tissue. Hence it is not the irritability of the stigma that prevents the growth of foreign pollen, but rather the specific chemical characters of the pollen-grains, pollen-tubes, and conducting tissue. Gärtner suggested that the irritability of the stigmas was necessary for the proper fertilisation of the ovules in the ovary, but Lutz shows that fertilisation occurs even when the stigma has become insensitive by age or rendered so artificially. Of course, the germination of the pollen is favoured by the closing process, which shuts the pollen grains into a moist chamber, and Lutz concludes that this is the sole advantage of the closing movement. When pollen is placed on the stigma carefully, so that no movement results and the lobes remain open, the grains germinate much more slowly than in the normal case where the lobes become closed. Lutz watched insects at work pollinating the flowers of *Mimulus*, *Torenia* sp., and others, and found that only very rarely did they place sufficient pollen upon the stigma to make it close permanently at once.

RECENT WORK ON EXPERIMENTAL MORPHOLOGY.—In 1908, Goebel gave an account of the interesting results already gained by experimental researches on alterations in structure induced by the action of external stimuli, or environment, and on the regeneration processes that occur when parts are injured or removed. In this work ("Einleitung in die experimentelle Morphologie der Pflanzen"), Goebel emphasised the necessity of studying a plant throughout its development as a condition for the understanding of its structure, pointing out examples that show great diversity between the corresponding parts of the young and the adult plant, and tracing these differences to causes whose action could be tested by experiment. Such experiments show that the action of the environment depends largely upon the period of growth during which it has acted, and that the characters of the earliest period may be retained in the normally later stages, or may be reproduced in these stages by the influence of an environment suitable to the earlier period. For instance, the common harebell (the "bluebell" of Scotland) shows rapid changes in the forms of its leaves as the result of changes in environment, these changes resulting from very different causes such as diminished light, lessened supply of water, increase in salts dissolved in water, and so on.

Goebel made the generalisation that these external influences act indirectly by altering the amount and kind of the food formed by the plant and needed to allow of the normal course of development, the external form being conditioned by the vital activity of the plant and by the food supply to each part of it. Goebel holds that the quality of the food supply explains the nature of the parts formed. For instance, the formation of stolons in the enchanter's nightshade (*Circaea lutetiana*) is attributable to the amount of organised food relatively to the inorganic ash constituents supplied to the growing-point of the stolon, being greater than that supplied to the leafy shoot. Again, if potato tubers are kept at a temperature not above 7°C., few roots or leafy shoots are formed, but new tubers develop rapidly, though remaining small; if the parent tuber is then cultivated at about 25°C., leafy shoots are freely formed, the younger tubers of the new growth often being changed into leafy shoots.

Dostál (*Flora*, 1911) has made a large number of experiments with *Circaea* and some other plants, and the results obtained by cultivating isolated pieces of stem, each piece with a single leaf and bud, are of great interest. He finds that axillary buds thus treated develop into either stolons (underground runners) or flowering shoots, or transitions between these two kinds of shoot, according to the position of the leaf and bud—whether taken from the base, apex, or middle of the plant. On the other hand, if the leaf is detached from the piece of stem, the bud always produces a sterile leafy shoot, no matter from what region of the stem it has been taken. Again, if, in experiments with a leaf and bud portion, the leaf is excluded from the light, the buds always grow into sterile leafy shoots. Dostál also finds that the development of a sterile leafy shoot depends upon the food supply; to produce a flowering shoot the proportion of organic to inorganic food must be greater than that required for the formation of a stolon. On the same material (food supply) conditions depend also the various characters of the kinds of shoot produced—their geotropic reactions (whether the shoot will grow upwards or horizontally when laid flat), the lengths of the internodes ("joints") of the vegetative stems and the inflorescences, the size and form and number of the leaves, the number of flowers, and so on.

Dostál's paper is of value as a careful and detailed working out of the experimental morphology of a single plant, on the lines indicated by Klebs and by Goebel. From the work of Klebs, we know that the normal course of development in any plant is only a special type of many developmental possibilities; that this normal sequence and no other is usually met with must be attributed to a normal sequence in the external factors. From Goebel's work, we gain further generalisations, some of which have already been mentioned.

In dealing with the production of buds in abnormal situations on various plants, Goebel shows that this is closely akin to regeneration, both being specially active at the growing-points of axes (stem or root) and of leaves; that adult tissue in various places may, however, revert to the

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embryonic state, these areas being along the veins; and that the impulse to development, apart from external stimuli, is conditioned by the presence of the necessary constituents of the food, brought about in leaves—when the leaf-stalk is cut—by the retention of the leaf's products within itself.

The phenomena of regeneration in plants have been much studied, and the results obtained by experimental researches, in which the plant is injured or has various organs removed, depend primarily for their interpretation on the fact that the various parts are correlated and influence each other. That is, we may assume that every organ arising from growing cells may develop in a variety of ways, and the direction of development which it takes depends upon its relations to other parts. When a stem or root is amputated, as in making cuttings, the new organ arising may be already present as a rudiment near the wound, or it may be formed from the healing tissue (callus). As a rule, leaves or parts of leaves cannot be replaced, but this does happen in some plants; as, for instance, in *Cyclamen persicum*, where new leaf-blades arise on the leaf-stalk when the blade of a young leaf has been cut off. Goebel states that in this case there is no real renovation of the leaf-blade, but simply a continued growth of the leaf-base, which was previously inhibited owing to correlation.

A remarkable feature in regeneration is the polarity of the organs and of the individual cells. If the tip of a shoot is removed, the bud nearest the wound develops: if the tip of a root is cut off, the nearest lateral root takes its place. A cut willow branch, bearing buds, will, if kept in moist air, produce at its upper end shoots only, and at its lower end roots only, whether it is placed right way up or inverted. The branch has an inherent polarity of its own, which was for long regarded as fixed; but Klebs showed that if the cork is removed from the upper end of a cut willow branch, and this end placed in water, roots will then develop from this end—by allowing enough water to enter, owing to the removal of the cork, the internal polarity of the branch is upset.

Doposcheg-Uhlár (*Flora*, 1911) has investigated the regeneration and polarity in various plants, and has obtained some remarkable results. He finds that the new shoots which arise from a very young fern-plant, still attached to the prothallus, when the growing-point of the plant is removed, strongly resemble the young fern produced from the fertilised egg; there arises first a "cotyledon" independent of the growing-point of the shoot. In some cases, moreover, the shoots arising from cut pieces of fern rhizome (underground stem) showed a curious leaf-like structure which protected the young growing-point, in much the same way as the cotyledon of the young fern plant protects the stem apex in its early stages of growth.

Many other interesting experiments are described by Doposcheg-Uhlár, whose paper is a model of patient and ingenious work directed towards the establishment of new facts, and the solution of the many problems arising from the stimulus given by Goebel in his invaluable *Einleitung*.

It is much to be hoped that Goebel's book will be translated into English. The earlier work on experimental morphology, regeneration, polarity, and allied topics is well summarised in Jost's "Plant Physiology" (Oxford Press).

SPORE DISPERSAL IN SELAGINELLA. — Various recent contributions to our knowledge of the genus *Selaginella* have been noted in these columns. This time we have to note an interesting paper by a German worker, F. W. Neger, who has described the shedding of the spores in *Selaginella helvetica* and *S. spinulosa*, in a recent number of *Flora* (N.F., Band 3, 1911).

In 1901, Goebel (*Flora*, Band 88) showed that in various species of *Selaginella* examined by him the megaspores are shed spontaneously, owing to a curious mechanism in the structure of the sporangium wall. The structure of the microsporangium is much simpler, the dehiscence mechanism being less highly developed, so that the microspores, despite their much smaller size, are scattered less widely than the large megaspores. He also showed that the cones or "flowers" of *Selaginella* are usually protogynous, that is, the megaspores are shed before the microspores, though the latter germinate much more rapidly. These arrangements tend to prevent self-fertilisation, or the fertilisation of the eggs, produced on germination of the megaspores, by the male gametes produced on germination of the microspores of the same plant.

Neger has investigated the dorsiventral creeping species *S. helvetica*, and the radially symmetrical erect species *S. spinulosa*. On each cone there occur at the apex microsporangia, at the middle both kinds of sporangia, and at the base microsporangia again. The apical microsporangia open first, then the two kinds of sporangia in the middle region, and finally the basal microsporangia. That is, in these two species the cones are at first protandrous, but after the emptying of the whole of the megasporangia there are always present undehisced microsporangia; there are two crops of microspores, some shed before the megaspores, and the rest afterwards. Hence during the whole of the period of shedding of megaspores there are ripe microspores ready to germinate.

In *S. helvetica*, Neger finds that the cones as well as the creeping vegetative shoots show dorsiventral symmetry, the upper leaves being small and the lower ones large. This species grows chiefly on vertical rock faces. In the middle region of the cone, which grows upwards from the creeping shoot, the megasporangia are chiefly found on the ventral side, the microsporangia chiefly on the dorsal side. This arrangement, which does not appear to have been previously noted, is attributed by Neger to the better nourishment of the ventral side owing to the larger leaves. Moreover, the ventral side is turned towards the light, and its leaves are, therefore, in a more favourable position for assimilation. Much more food is, of course, required by the megaspores, the tissue of which has to nourish the developing embryo, than by the minute microspores which merely have to produce a few antherozoids. Since *S. helvetica* grows in sheltered clefts and crannies, wind can only play a small part in the dispersal of the spores. The dehiscence mechanism of the megasporangium is well developed, but this mechanism would be of little use were the megasporangia on the shaded dorsal side of the cone—the liberated megaspores would then strike the vertical rock face close to the plant and roll off or become entangled in the vegetative shoots. The minute microspores, however, are easily carried away by the lightest breeze, and the dehiscence mechanism in the microsporangium wall is so feeble that the spores on being set free hardly reach the substratum close by. In *S. spinulosa*, which forms horizontal patches with the shoots orthotropous (erect), the cone shows no differentiation into light and shade sides; the megasporangia are found all round the axis of the cone, and the megaspores on being set free have a clear path in all directions.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

BIOLOGICAL ACTION OF RADIUM.—Dr. Loewenthal writing in the *Zeit. angewandt. Chem.*, 1911, XXIV, 1130, points out that the therapeutic action of certain mineral water springs must be attributed, partially at all events, to their containing a considerable proportion of radium. It is well known that radium emanation has a pronounced stimulative effect upon the enzymes (pepsin, trypsin, diastase) present in the body, and the beneficial effects of these springs are probably due to this cause. Young plants and mould-fungi are also favourably influenced by the action of a small quantity of radium emanation, but they are injured by larger amounts. The action of the radium emanation has also a marked effect upon the white corpuscles of the blood, and it has been proved by Gudzent that the same body increases the solubility of sodium urate. This effect, however, is attributed to the action of the product of decomposition of the emanation termed "radium D." On this fact has been based a method

of treating gout by the application of radium emanation, and it is claimed that the treatment has given good results.

RADIUM IN URANIUM ORES.—An estimation of the amount of radium present in various uranium ores has been made by Messrs. Marckwald and Russell (*Chem. News*, 1911, CIII, 277), who have taken the ionising power as a measure of the radium. Comparing the ratio of the radium to uranium with that of Joachimsthal pitchblende (taken as 100), they have obtained a value of 98·1 for thorianite, and 101.5 for African pitchblende, but for autunite values ranging from 20·7 to 68·0, although the ratio of ionium to uranium was much more uniform in this mineral. Since the life of ionium is not less than thirty thousand years, the conclusion is drawn that autunite must be at least one hundred thousand years old, and that, therefore, the relatively low values for the radium ratio are not due to the radium being of recent formation. It seems more probable that the physical structure of autunite is responsible for the difference, and that owing to its possessing a much more spongy texture than pitchblende and thorianite, the radium and lead have been partially extracted by water from the mineral. This view is supported by the fact that there is only a slight occlusion of helium in autunite, and by analogous results obtained in the examination of the mineral rutherfordite.

PROPERTIES OF METALLIC TITANIUM.—It is not an easy matter to obtain the element titanium in a pure condition, as is shown by the account given by Messrs. Hunter and Jones (*Rensselaer Polyt. Inst.*, No. 1, February 11th, 1911), of their attempts to prepare it. The products obtained by reducing sodium, potassium, and barium titanifluorides with potassium in no instance contained more than 73·2 per cent. of titanium, while reduction of titanium oxide by means of carbon invariably yielded products containing upwards of five per cent. of carbon. Finally pure titanium was prepared by heating together in a closed bomb a mixture of titanium tetrachloride and metallic sodium, with the greatest precaution to exclude all air. The reduction took place almost instantaneously at a dull red heat, and products, which on analysis showed from 99·9 to 100 per cent. of titanium, were obtained.

As thus prepared titanium was a hard brittle metal resembling polished steel in appearance. It melted between 1800° and 1850° C., and had a specific gravity of 4·50. It could readily be forged.

CHEMICALLY ACTIVE NITROGEN.—Pure nitrogen that has been subjected to an electric discharge from a Leyden jar undergoes a remarkable change, an account of which is given by the Hon. R. J. Strutt, in a recent issue of the *Proceedings of the Royal Society* (1911, LXXXV, 219). The gas after being removed from the region of the discharge continues to glow during the process of returning to its normal state. The glow is intensified by cold but diminished by heat, and it is suggested that it may be due to the dissociated atoms entering into combination again.

In this chemically active condition, nitrogen forms a compound with ordinary yellow phosphorus, while a large amount of the phosphorus is transformed into the red modification during the reaction. It also enters into combination with sodium and with mercury at relatively low temperatures, the mercury product being an unstable explosive body; while there is spectroscopic evidence that similar compounds with other metals, such as cadmium and magnesium, are produced.

When brought in contact with nitric oxide glowing nitrogen reacts to form nitrogen peroxide, the reaction probably taking place in accordance with the equation—

$$2\,NO + N = NO_2 + N_2$$

It also effects the decomposition of acetylene and of chlorine and bromine derivatives of hydrocarbons, with the liberation of the halogen and formation of cyanogen.

MINERAL CONSTITUENTS OF A DUSTY ATMOSPHERE.—A spectroscopic method of determining the nature of the dust in the atmosphere has been devised by Professor Hartley (*Proceedings of the Royal Society*, 1911, LXXXV, A. 271). A series of photographs of spark spectra was taken upon one plate, and compared with a similar series taken in an atmosphere of hydrogen, the differences showing which of the lines were due to impurities in the metal electrodes and which to the dust in the atmosphere.

It was found that the calcium and copper lines were intensified as the proportion of dust in the air increased, with the continuance of dry weather. With regard to the source of the copper it is pointed out that this element is present in coal-ash, and in the dust from the flues of chemical and gas works, and that it is also introduced into the atmosphere by the flashes of overhead cables; while the amount of calcium is increased by tram and motor car traffic. In fact the possibility of the copper or calcium in the atmosphere acting as reagents, must be taken into account in all cases of apparently spontaneous changes such as might have been set up by traces of basic substances. They may also produce alterations in solutions that would not be affected by exposure to a pure atmosphere.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

NEW THEORIES OF VULCANISM. — R. A. Daly (*Proc. Amer. Acad. of Arts and Sciences.* Vol. XLVII, No. 3, 1911, pp. 45–122) bases a paper on "The Nature of Volcanic Action" on his well-known theory of abyssal injection. He believes that the world-wide granitic terrane underlying the interrupted sedimentary shell is itself underlain by a shell of eruptible basalt, which is the source and "heat-bringer" of all igneous action. He points to the fact that all the great lava-floods of the world are of basalt, and have welled out from great fissures which are supposed to have tapped this basaltic substratum, although it is not supposed that simple openings extend to this depth.

Other igneous rocks are believed to be due to the absorption of the overlying acid shell, as abyssal injections of basalt, caused by crustal deformation, work their way upwards by a method known as "stoping." This involves the constant wedging away of blocks from the roof of the resulting batholith, and their solution in depth. The resulting mixed magmas are called "syntectics," and with or without subsequent differentiation, are held to give rise to the known variety of igneous rocks.

Daly holds that vulcanism is a subsidiary effect of abyssal intrusion. He distinguishes three phases of volcanic action—fissure eruptions, in which lava rises with great rapidity through relatively thin cracks in the crust; eruptions through local foundering of the roof of a batholithic intrusion; and central eruptions of the common cone and crater type. Fissure eruptions are well known, and beside the recent Iceland examples, there are numerous others belonging to past ages. The Yellowstone Park rhyolite is believed to be an example of the second type of volcanic action. This huge mass of lava, cut by canyons to a depth of six hundred meters without revealing its base, lacking horizontal division-planes indicating successive flows, is without parallel amongst lava-flows. Daly believes that it passes gradually downwards into a batholithic mass of granite, and is due to the foundering of part of the roof of this batholith, whereby the molten rock was solidified under surface conditions.

Central eruptions are supposed to originate in a cupola-like extension of the roof of a batholithic intrusion, where "stoping" action would be intensified by a concentration of the hot volatile magmatic fluids. On reaching the surface the "cupola" would originate a volcanic focus, and a cone would be formed. At this stage the problem of the continuance of the volcano becomes the problem of the continuance of heat within the funnel.

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There are five conceivable methods whereby heat may be transferred from the magma to the vent:—

i. Explosive removal of material from the upper part of the vent, followed by uprise of magma.

ii. Simple outflow of magma at the crater-lip.

iii. Thermal convection in the lava column.

iv. "Two-phase convection."

v. The uprise of super-heated juvenile gas through the lava column.

At Kilauea, on the observation of which this theory is partly based, the first and second methods are inoperative; the third is known to be inefficient in heat-transfer; but the fourth, a process conceived to be due to the uprise of comparatively-light, hot, gas-permeated magma in the lava-column, and its return along the margins of the vent as comparatively heavy, cooled, gas-free magma,—may bring a considerable quantity of heat to the surface. This process is believed to be the cause of the lava-currents in the crater of Kilauea. The fifth method may be efficient as a heat-bringer at some vents, but not at Kilauea.

A largely overlooked source of heat, according to Daly, is that set free by chemical reaction between the constituents of the hot and active magmatic fluids. Many striking figures are given illustrating the great amount of heat evolved by the reactions between the common elements of these fluids.

The process outlined above is known as the "gas-fluxing hypothesis," and is considered analogous to that of a gas-blowpipe.

Some explosive types, such as the Ries cauldron and Bandaisan, are considered due to the contact of hot magmatic material with vadose waters circulating within the rocks. The explosions here are non-volcanic; but there may be all gradations between this type, and those, such as the Hawaian volcanos, characterised by quiet magmatic extrusion without explosion. In ordinary volcanoes, there are great variations in the proportions of magmatic and vadose fluids involved, and consequently great variety in modes of eruption.

With regard to the now much-discussed rôle of steam in volcanic action, Daly says: "Though the rise of hot magma into rocks charged with vadose or connate water does often cause explosion, the steam pressure produced by such volatilised water can no more be regarded as the cause of vulcanism than is the boiling of a kettle the cause of the heat in the stove."

A. BRUN.—Whilst Daly emphasises the adventitious nature of the intervention of water in volcanic action, it is to Brun, of Geneva, that we are indebted for what appears to be the overthrow of the old axiom that paroxysmal eruption is due to the explosive violence of steam. In the *Geological Magazine* for June and July, Mr. E. B. Bailey, of the Geological Survey, gives an illuminating review of the new book, "Recherches sur l' Exhalaison Volcanique" by this original and courageous worker. One of the most valuable features of Brun's work is the mass of new and exact experimental data he has accumulated in respect to vulcanicity. Not only has he measured the temperature constants of many minerals found in lavas, but new work has been done in the methods of collection, extraction, and analysis of the various volcanic gases, both in the field and in the laboratory. Experimental work on the behaviour of rocks during heating has resulted in their classification as "active" or "dead." Active rocks, typified by recent lavas, expand and liberate gas at such a rate when heated that the molten material fumes over the edge of the crucible, like a miniature lava flow. Active acid rocks are more violent than basic and give rise to veritable explosions. Dead rocks, among which are schist, granite and gabbro, give off gas during heating, but at a higher temperature melt quietly without much expansion or violence. The temperature at which gas is emitted in active rocks so rapidly as to cause sudden expansion and explosion is called the "explosion temperature." The maximum temperature possible at a volcano is fixed by the explosion temperature of its magma.

The principal gases liberated at the explosion temperature are chlorine, hydrochloric acid, and oxides of carbon; the solids evolved are chlorides of the alkali metals and ammonium; sulphur occurs but is always in small quantity. Such water as is contained in the rock is always given off before the explosion temperature is reached. These constituents, with the exception of carbon monoxide, are the same as those actually emitted at volcanoes.

Brun's main thesis is that paroxysmal eruptions are anhydrous, and that the aqueous character of fumaroles is due to the contact of volcanic heat with superficial waters. This view is supported by many striking observations. It is shown, for example, that near the crater of Vesuvius, the ashes fall quite dry, but are extremely hygroscopic, owing to the presence of chlorides of iron and magnesium. Morever, the ash which falls is white; whereas if it had been exposed to the action of water vapour at a high temperature, it would redden immediately, owing to its content of ferrous chloride. In the crater itself, such deliquescing salts as Fe_2Cl_6, $Fe\,Cl_2$, $Mg\,Cl_2$ and Al_2Cl_6, may be collected dry and undecomposed, whilst hot water-vapour would immediately reduce them to oxides.

Further evidence is adduced from the study of the white clouds which hang over volcanoes. These are generally regarded as water-vapour; but Brun shows that they are persistent, and insoluble in the atmosphere as they drift away from the volcanic focus, and are therefore composed of solid particles. At Kilauea, Brun took a series of dew point readings in the great white cloud as it drifted across the crater-lip. His results show in every case a lower dewpoint for the air within than for the air outside the cloud. The lowered dew-point is believed to be caused by the dilution of the air with anhydrous gases carrying hygroscopic solids in suspension. On the contrary, a markedly elevated dewpoint was obtained at the peripheral fumaroles, as was, indeed, to be expected.

It seems, therefore, that Brun has, at least, established the anhydricity of volcanic exhalations; and great probability attaches to his view that water is not the agent to which paroxysmal eruptions must be attributed.

METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

The weather of the week ended July 22nd, as summarised in the Weekly Weather Reports of the Meteorological Office, was very fine over the greater part of England, but slight rain fell in the North and West and in Ireland. In Scotland there was frequent rain, though it was seldom heavy. Thunderstorms were reported during the middle of the week.

Temperature was again above the average, except in Scotland, where it was either normal or very slightly below. Very high maxima were recorded in the South and East of England and in the Midlands, the highest being 96° at Greenwich, on the 22nd, with 94° at Margate and 93° at Raunds. In Ireland the highest reading reported was 79°, while in Scotland North and West the temperature did not rise above 71°. At individual stations in Scotland and Ireland the maximum did not reach 70°, and at Balta Sound, Shetlands, it was only 59°.

The minima were above 40° everywhere except in Scotland, where, at Balmoral, the temperature in the screen fell to 32°, and on the grass to 30°. In the English Channel the minimum was 55°.

Rainfall was below the average except in Scotland N. and E. The defect was very great in places, and the drought began to be severely felt. In England S.E. the week was rainless.

In Scotland, however, there was much rain, the total for the week exceeding 2·0 inches at Glencarron and Fort William.

Bright sunshine varied a good deal. In most parts of England it was again above the average, but in Ireland, Scotland and the Northern parts of England it was in defect. In Ireland N. the average daily duration was less than three

hours, while in England S.E. it was over eleven hours. The percentage of possible duration varied from eighteen per cent. in Ireland N. to seventy per cent. in England S.E. and in the English Channel.

The temperature of the sea water was generally high, the means varying from 52°·5 at Lerwick to 65°·9 at Margate.

The weather of the week ended July 29th, was more variable than that of the preceding week. In Ireland it was unsettled, with frequent rain. Many thunderstorms were reported, that in London, on the 28th, being very severe. Temperature was above the average in all parts, the excess exceeding 7° in England E. and S.E. The maxima were again unusually high, though not quite equal to those of the preceding week. The highest readings were 93° on the 29th, at Bath, 92° at Tunbridge Wells, and 91° at Fulbeck, Oxford, Raunds, Cardiff and Clifton.

The minima for the week ranged from 37° at Balmoral to 57° at Scilly. On several nights the minima over a large part of England were as high as 60°. On the grass the readings did not, as a rule, fall below 40°, but at Burnley, Balmoral and Crathes, readings of 34° were observed, and at Llangammarch the exposed thermometer registered 29° or 3° of frost.

Rainfall was much less than the average in most parts of England, but was more than usual in Scotland N. and W., in Ireland and the English Channel. In Ireland S. the total was two and a-half times as much as usual.

During the thunderstorm in London on the 28th 1·1 inches of rain fell in South Kensington in fifteen minutes. On the next day 1·21 inches fell in Dublin in forty-five minutes, and 2·14 inches at Kilkenny in two and a-half hours.

Bright sunshine was again in excess in England, but was deficient in Scotland and Ireland N., and just normal in Ireland S. The sunniest stations were Weymouth with 83·5 hours (77%) and Salcombe 82·6 hours (77%). On the other hand, at Fort Augustus only 11·9 hours (10%) were recorded, and at Nairn only 14 hours (12%).

The mean temperature of the sea water round our coasts varied from 52°·7 at Lerwick to 67°·6 at Eastbourne.

The week ended August 5th was unsettled, but the rainfall over England E. and S.E. was again very slight. Thunderstorms were experienced in most parts, and in some cases these were accompanied with very heavy showers. Temperature was above the normal in all districts, by as much as 7°·1 in England E. The highest maxima reported were 88° at Cambridge on the 30th July, with 87° at Cromer and Hillington, and 86° at Greenwich. In Jersey the highest reading was 76°. The lowest readings varied much. At West Linton the minimum was 42°, and readings below 50° were reported at many stations. The lowest reading reported at Jersey was 57°. No frost on the grass was reported during the week.

Rainfall was largely in excess in most of the western districts, but over the rest of the country it was still in defect, and in England S.E. it was less than one-fourth the usual amount.

Sunshine was in excess in all Districts except the English Channel where it was slightly in defect. The district values ranged from 63 hours (59%) in England E., to 35 hours (32%) in Ireland N. The sunniest stations were Felixstowe 72·8 hours (68%) and Clacton 71·7 hours (67%). At Westminster the total duration was 55·9 hours (52%).

The temperature of the sea water varied from 53° at Lerwick to 71° at Margate.

The week ended August 12th, was very fine and dry, though with slight rain in Ireland and Scotland, and some thunderstorms. Temperature was remarkably high and in England E. the district mean was as much as 9·2 above the average. In most parts the hottest day was the 9th, when temperatures higher than any previously recorded in the United Kingdom were reported. The highest reading was 100° at Greenwich, which is the highest reported since precise observations were begun there in 1841. The previous highest was 97°1 in July, 1881. Other very high readings were 98° at Raunds, Epsom and Canterbury, and 97° in London, and Hillington, Norfolk.

Dr. H. R. Mill, the head of the British Rainfall Organization, writing in *Symons's Meteorological Magazine* says that the maximum temperature at Camden Square was 97°·1 at 2.15 p.m. on August 9th, the previous highest, since the record began in 1858, being 95°·2 in July, 1900. On the same day at Mill Hill, 380 feet above sea level, while the maximum in the Stevenson screen was 95°·8, Mrs. H. R. Mill noted the reading of a black bulb thermometer *in vacuo* as 142°·4. On July 22nd this year, however, with a screen reading of 90°·0, the black bulb was as high as 146°·8.

The lowest readings ranged down to 41° at Wick and to 42° at Gordon Castle. In Jersey the minimum for the week was 59°, and on several nights over a large part of England the temperature did not fall below 60°. No ground frost was reported, but at Crathes the exposed thermometer fell to 33°.

Rainfall was largely in defect in all districts, and over the greatest part of England it was very slight indeed. At many stations the week was rainless.

Sunshine exceeded the average in all districts, the values in England S.E., being 79 hours (76%). The sunniest stations were Felixstowe, 88·2 hours (84%), Brighton, 86·9 hours (84%), and Hastings, 86·2 hours (83%). The mean temperature of the sea water ranged from 55°·0 at Lerwick to 68°·3 at Margate.

An unmanned balloon sent up at Mungret College, Limerick, on July 6th, reached a height of thirteen miles. The lowest temperature met with on this ascent was −57° C., at about seven and three-quarter miles above the ground.

MICROSCOPY.

By A. W. SHEPPARD, F.R.M.S.,

with the assistance of the following microscopists:—

ARTHUR C. BANFIELD. ARTHUR EARLAND, F.R.M.S.
THE REV. E. W. BOWELL, M.A. RICHARD T. LEWIS, F.R.M.S.
JAMES BURTON. CHAS. F. ROUSSELET, F.R.M.S.
CHARLES H. CAFFYN. D. J. SCOURFIELD, F.Z.S., F.R.M.S.
C. D. SOAR, F.L.S., F.R.M.S.

MICRO-FAUNA OF A SEWAGE FILTER BED.—This short note is the result of isolated observations I have made from time to time, over a number of years, as occasion or necessity arose for paying a visit to the works where the process of sewage purification is carried out. The large variety of bacterial fauna present in such a nidus will not be touched upon, but only that part of the life which can be readily observed by the average microscopist. The bulk of the organisms herein noted, can be examined in a cursory way with a good pocket lens.

A sewage bed, as most of my readers are probably aware, is a specially constructed area for dealing with liquid sewage. The particular type to which this note relates is circular in plan, and is filled to a depth of about six feet, with a specially prepared material or "media," as it is termed, which forms a "nidus" or breeding ground for the bacteria responsible for the process of purification. The "media" is prepared from what is known locally as "Blast Furnace Slag" broken to varying degrees of fineness, ranging from a quarter of an inch to two inches in gauge. The sewage is applied to the surface of the bed by a travelling form of distributing apparatus similar to an elongated water wheel, which has a circumferential together with a rotary motion on its own axis, and so sprinkles the sewage evenly and regularly over the whole area of the bed.

On taking up into the hand a piece of the "media" one is struck with the gelatinous covering, which forms as it were a sort of blanket enveloping the whole piece under examination. This covering consists largely of bacterial life which is outside the scope of this note.

The first form of active life noticeable consists of a large number of small black bodies which, on a closer inspection, reveal themselves as a sort of "fly." They are very different

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from the fly as the ordinary individual observes them, and if a piece of "media" is taken in the hand and the "flies" shaken off on to a piece of white paper, they will be seen to move about by a series of sudden sharp jumps, sometimes covering a considerable distance in comparison with their own length. They belong to the Order Collembola and are referred to by microscopists in popular language as "Springtails." To give the reader some idea of the immense number found on a bed I have on many occasions observed an area of four to six feet (superficial) covered to a depth of one quarter of an inch. These insects are not confined solely to the surface of the bed. On digging out the "media" they will be found to a considerable depth, but in much smaller numbers.

The next dwellers in this odorous habitation are, strange to say, our very interesting friends, the spiders. My friend, Mr. F. P. Smith, some little time ago, identified a collection for me as consisting of two species, viz., *Porrhomma microphthalum* and *Tmeticus simplex*, the latter by no means a common species. Both sexes of each were taken. While on the subject of spiders it may be interesting to mention that during certain months of the year it is a common spectacle to find in the early hours of the morning the whole surface of the bed covered with a network of webs. It is an extremely pretty sight, and I have several times endeavoured to take photographic records, but without any satisfactory measure of success. The spiders, like the "Springtails," appear to be equally at home in the depths of the bed. In fact, they are much more evenly distributed.

On the bottom of the outlet channels there is usually a layer of finely divided mud, or "humus" as it is termed, and on skimming this layer one can generally obtain the Desmid *Closterium ensis*, but not in very large numbers. Amongst the Protozoa there are specimens of *Arcella*, *Actinophrys sol*, and *Difflugia*. Coming to the Infusorians there are found *Coleps*, *Stentor* and *Vorticella*, the latter forms sometimes being taken in large numbers. The slipper animalcule *Paramoecium*, it is almost needless to say, can always be found.

Amongst the Entomostraca specimens of *Cyclops* are plentiful, together with *Daphnia pulex*.

A few Rotifers are sometimes taken, and the same remark applies to *Volvox globator* and the freshwater polype *Hydra viridis*.

The variety of microscopic life would probably be larger, but owing to the method of working, and the constantly changing character of the sewage, it is somewhat surprising to find the variety herein enumerated.

A peculiarity which can perhaps be easily accounted for is that whilst it is possible to keep specimens of the forms mentioned in captivity for considerable periods of time, when the collection has been taken from a freshwater pool, this is not the case with those collected from this particular gathering ground. Vorticella and the larval forms of *Cyclops* die very quickly unless the collection is poured out into a shallow dish. In this way I have kept the several forms of life in an active condition for a considerable time.

GEO. P. DEELEY.

ANABAENA CIRCINALIS.—The water in one of the ponds near Totteridge Common, visited by the Quekett Microscopical Club on their Saturday afternoon excursion late in June, was of a decided green colour, almost like green pea soup.

FIGURE 1. *Anabaena circinalis.*

The appearance was caused by the presence of many different species of minute algae, most of them of an indefinite character, such as would be classed with the Protococcaceae and Palmellaceae,with some *Scenedesmus* and zoöspores of various kinds. But the greatest effect was produced by a less doubtful plant. It was so plentiful that it was not necessary to concentrate the take with the net; it could be obtained abundantly for examination by merely dipping a bottle into the water. It obviously belonged to the not very easily discriminated family —the Nostocaceae—and was probably *Anabaena circinalis* (Figure 1). It consisted of free-swimming short filaments, composed of roundish cells averaging about 4μ in diameter, with bluish-green coarsely granular contents. The filaments were twisted into helical coils of from two to six turns, or occasionally even more, often very symmetrically arranged. Most of the coils had intercalated in them a rather larger quite spherical cell with clear contents—the heterocyst. Sometimes a spore also was present: these are oval, granular and larger than the ordinary cells. Vegetative cells undergoing division were not uncommon; in this case they were larger than usual and more or less constricted in the middle, according to the stage the process had reached. A singular feature was, that the direction of the spiral in most cases changed at the heterocyst; this is shown in the top and bottom examples in the figure. When the filament was a short one, this gave rise to a peculiar M-shaped form with turned up ends, as shown in the extreme left hand example. This form was very plentiful. Various species of *Anabaena* are not at all infrequent in the freshwater plankton but the present variety is certainly not very common.

The specific determination of many of the lower algae is very difficult with the text books at present accessible to the ordinary microscopist, and everyone desiring to study this interesting class must be anxiously awaiting the appearance of Professor West's anticipated work, with fuller details than were possible in his "British Freshwater Algae" published in 1904.

J. B.

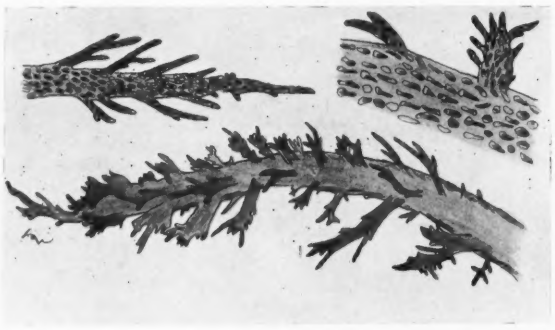

FIGURE 2. *Hydrurus foetidus* Vill.

HYDRURUS FOETIDUS (VILL).—In the August number of "KNOWLEDGE" (page 320), a note was published on the above, but the subject proved too difficult for photography; we are, however, now able to reproduce drawings of the plant (Figure 2). The lower drawing represents a small, sparsely-branched plant; usually the branches are much closer together and of a more filamentous character. Above, on the left, such a branch is figured, and shows the small coloured bodies embedded in the gelatinous matrix. On the right is a small piece of a thicker stem, showing the same bodies and their arrangement in that part, where they become more elongated and less frequent than in the thinner portions of the plant. The magnifications are approximately × 25, × 70, and × 180 respectively.

J.B.

ENTAMOEBA COLI.—In the *Annals of Tropical Medicine and Parasitology*, Vol. V., page 111, appears a paper by Dr. H. B. Fantham, "On the amoebae parasitic in the human intestine, with remarks on the life-cycle of *Entamoeba coli* in cultures." The amoebae begin to encyst on the culture-media which the author has been using, in about four days, the cyst wall of each being formed by differentiation at the periphery of the now rounded amoeba.

The cyst at first contains a centrally-placed nucleus, with a karyosome. Inside some of the cysts division occurs, and eight daughter forms are produced.

The author tried the effect on *Entamoeba coli* of "auxetics," substances such as tyrosin and leucin, occurring naturally in the human body and capable of inducing division in living cells. The substances are best used in a jelly with agar, sodium chloride and an alkali (sodium bicarbonate), forming a slightly alkaline culture medium. When such a medium containing about 0·2 per cent. of tyrosin is inoculated with cysts of *Entamoeba coli*, the period of the life-cycle is shortened and the amoebae in the culture reproduce for several generations. The author mentions a culture which had gone through five generations. One interesting and novel result on tyrosin-containing media is that a complete life-cycle of *Entamoeba coli* is passed through in about three days (at 20° to 25° C.), when all the amoebae of a given generation have encysted. Then a large number of the cysts produce eight daughter forms inside them, and the amoebulae come out of the cysts and start a new generation in the same medium. The process of binary fission which also frequently occurs in such media involves a primitive mitosis (or promitosis) of the nucleus, caps of chromatin derived from the karyosome being formed at the ends of the rudimentary spindle.

The subject of this research, *Entamoeba coli*, is usually considered to be non-pathogenic; it lives in the lumen of the large intestine and on the contents thereof; it is incapable of penetrating the mucosa. The size is slightly variable from 12 to 25 μ in diameter.

G. PLANT DEELEY.

ORNITHOLOGY.

By HUGH BOYD WATT, M.B.O.U.

A NEW BRITISH BIRD—THE ALPINE RING-OUZEL.—The occurrence of this form of the Ring-Ouzel (*Turdus torquatus alpestris*) is recorded for the first time in Great Britain by Mr. M. J. Nicoll, in *British Birds* (V, August, 1911, pages 72–73), on the strength of an adult male shot at Guestling, Sussex, on 23rd May, 1911. The illustration given shows the form to be generally whiter in appearance than the common Ring-Ouzel. The Alpine bird has a wide range, extending in the breeding season throughout middle and south Europe to the Balkans.

THE IRISH COAL-TITMOUSE—(*PARUS HIBERNICUS*).—In the current number of *The Ibis* (9th Series V, July, 1911, pages 548-552), Mr. W. R. Ogilvie-Grant gives what may be taken to be a definite finding on this bird (see "KNOWLEDGE" for March, 1911). He modifies his earlier claim for its full specific rank, and, as the British Coal-Titmouse also occurs in Ireland, and the two forms to some extent intergrade, he now regards the Irish bird (*P. hibernicus*) as a sub-species only, though a very distinct one.

Mr. Ogilvie-Grant makes the suggestion that some characters of the Irish bird indicate that its origin is much more ancient than its British representative, and that it is a pre-glacial type which has survived in the western and southern parts of Ireland. He points out that the form most closely allied to the Irish bird is, in many respects, another Coal-Titmouse (*Parus ledoucii* Malh.,) peculiar to Algeria and that the Lusitanian element in the fauna of Ireland is illustrated by this. He remarks that the distribution of the Strawberry tree (*Arbutus unedo*), which has a wide range in the Mediterranean region and is found in the neighbourhood of Killarney as well as in Algeria, is most interesting, as bearing on the question of the Irish and Algerian Titmice. What bearing the interest exactly has on the case of the Irish Coal-Titmouse is not stated.

GROUSE AND DISEASE.—"No disease" is the prevailing report from grouse moors this season, and in addition to the healthy state of the birds their numbers in Scotland are believed to be greater than in any past year. This exceptionally good season coincides with the publication of the elaborate report of the Committee on Grouse Disease, the result of some six years investigations, under the Chairmanship of Lord Lovat, the general questions being treated by Mr. A. S. Leslie and Dr. E. A. Wilson and the scientific by Dr. A. E. Shipley.

According to the experts, who have gone into the whole matter with a thoroughness that entitles them to utter the last authoritative word on the subject, the one disease among grouse that spreads havoc and desolation among the birds is caused by what Lord Lovat—turning the expert's highly technical nomenclature into the plainest possible language—terms an over-infection of the Strongyle worm—a worm that is found in practically every grouse on a moor; that is to say (to quote Lord Lovat), "that almost every bird (grouse) contains in its body, under normal conditions, the immediate cause of "grouse disease," and is to a greater or less extent an agent for the dissemination of that scourge." This means that the Strongyle worm will be found to-day in practically every one of the unusually numerous and healthy grouse on practically every moor in Scotland. And the Strongyle worm has always been there, but where and when the grouse—so to speak—are stronger than the worm there is no "disease." The "disease" breaks out when and where the worm is stronger—so to speak—than the bird, although of course the strength of the worm has nothing to do with its name. It follows, therefore, that in the present year, with grouse so healthy everywhere, the conditions must have been such that the birds have been able to keep their worms under proper check, and if that be so it is evident that to those in any way skilled in moorcraft—with the Committee's two sumptuous volumes in their hands, and by a study of the conditions—there should now be little difficulty in so managing grounds and grouse alike that the largest possible stocks of the healthiest possible birds should be the result.—*The Glasgow Herald*, 12th August, 1911.

There is every likelihood that the sport will be so managed during the present season that 1912 should prove as healthy a grouse year as 1911—if the weather also help as it has undoubtedly done during this and last year. According to Lord Lovat, in his admirable chapter on moor management in the Committee's final report, "the immediate objective of the moor owner (who wants good stocks of healthy grouse) stands out clearly—to keep the Strongyle infection at its lowest, to keep the power of resistance of the stock at its highest, and at the same time to maintain the greatest number of birds that the moor is capable of supplying with suitable food." To put it briefly and in practical language, his Lordship sums up the whole matter in these further words—"Moor management is the science of distributing the stock of birds over the moor so that at no period of the year can any area be so infected by the Strongyle worm as to make it a source of danger to the least well-nourished bird on that area."

MARKING BIRDS AND MIGRATION.—There are some reasons for looking with dubiety on the various bird-marking schemes now in operation. Their partial and limited scope, and the danger of making general deductions from the meagre returns obtained, are fair points for consideration, and also the destruction of bird-life which may be entailed in procuring these returns, although such destruction is not approved of by the inquirers. Those who share such apprehensions are recommended to study Mr. A. Landsborough Thomson's recent paper on "The Possibilities of Bird-Marking, with special reference to the Aberdeen University Bird-Migration Inquiry" (*Proceedings Royal Physical Society, Edinburgh*, XVIII, 3, 1911, pages 204-218), which gives, in admirable terms, a well-considered and reasoned statement of the subject. Apart from general and historical and other results, of which a good and valuable account is given, covering Great Britain, the Continent and the U.S.A., the paper tells of the particular investigation now in hand at Aberdeen. This has the advantage of being a piece of research work organised under a responsible body, viz., the Natural History Department of the

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University of Aberdeen. Properly controlled methods and results should accordingly be assured, and, while Mr. Thomson writes as an enthusiast, he does so judiciously, and does not overlook the difficulties nor exaggerate the possibilities of the subject.

For some of the Aberdeen returns already reported see "KNOWLEDGE" for May, 1911 (page 198).

We wonder why so few or no returns seem to be forthcoming from one class of birds, viz., the game-birds which, owing to the numbers meeting death from the hands of man, would seem to be likely to yield a larger percentage of returns to the numbers marked than any other class of birds. We do not overlook the returns regarding Woodcock, but refer more particularly to Grouse, Partridge and Pheasant.

ACCLIMATIZING PARADISE-BIRDS.—As stated in "KNOWLEDGE" for June, 1911 (page 237), Sir William Ingram has bought the uninhabited island of Little Tobago, West Indies, and is attempting to acclimatize the Greater Bird of Paradise (*Paradisea apoda*) there. In the *Avicultural Magazine* (II, 5, 1911) he reports that he has turned out forty-eight birds and that two others were to be sent later. The island consists of four hundred acres of forest jungle and the birds have spread over the whole area. They eat fruit, insects and young birds and eggs of other species. Four are known to have died, and none have yet mated.

PHOTOGRAPHY.

By C. E. KENNETH MEES, D.Sc.

LATITUDE OF EXPOSURE IN LANDSCAPE PHOTOGRAPHY. — It is well-known that in landscape photography there is very considerable latitude in the exposure which may be given, a range which is sometimes ascribed to the latitude of gradation which the photographic dry plate is capable of accurately rendering. Experimental investigation, however, shows that the range of light intensities which can be reproduced accurately by an ordinary photographic dry plate is only about one to twelve or one to sixteen, that is to say, this is the range of intensities which are included in the straight line portion of the characteristic curve of a plate, or is the range of intensities comprised within the period of correct exposure of a plate.

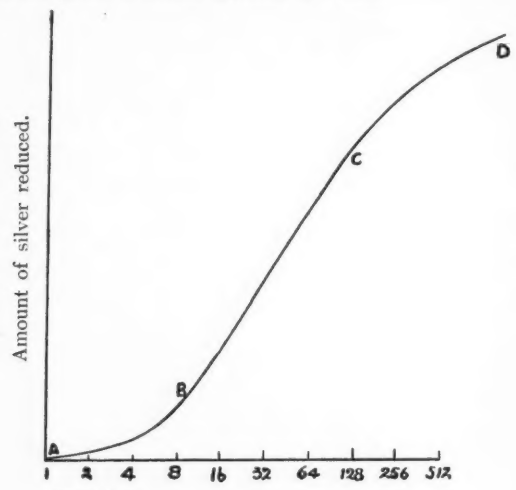

FIGURE 1.

The figure shows the "characteristic curve" of a plate, that is, the relation between the light intensity acting on the plate during exposure and the amount of metallic silver reduced by development.

It will be seen that this curve may be divided into three portions:—A portion, AB, where the reducible silver increases more rapidly than the geometrical increase of the intensities, a portion, BC, where the increase rates are proportional, and a portion, CD, where the increase of silver with increasing exposure diminishes.

These three portions are known:

AB, as the period of under-exposure,

BC, the period of correct exposure, and

CD, the period of over-exposure.

For the curve shown the range of intensities in the period of under-exposure is about one to eight, the range in the period of correct exposure eight to one hundred and twenty-eight, or one to sixteen.

Since one to fifteen is about an average range of intensities for an ordinary landscape subject, it is obvious that, strictly speaking, a plate has no latitude at all, that is, any deviation from one fixed exposure, which we may call correct exposure, will cause one end or other of the intensity scale to fall out of the period of correct exposure of the plate, so that, except for one particular exposure, an average landscape must have some of its intensity scale rendered either within the under- or over-exposed periods of the plate curve.

In practice a plate is not considered under exposed provided that any deposit at all is obtained in the deepest shadows, which implies that instead of the effective range of light intensities starting at the beginning of the period of correct exposure, in practical photography the range of light intensities starts at the beginning of the period of under-exposure, and the rule that the exposure should be given for the shadows—the safest of all rules in landscape photography—means that the range of intensities on the resulting negative will be represented in both the under-exposure and correct exposure periods of the plate curve. An increase of four times this exposure will merely serve to shift the shadow exposure from the beginning of the under-exposure region to the beginning of the correct exposure region of the curve, and we may therefore expect an apparent latitude of at least one to four in the direction of over-exposure. If we again increase the exposure, we may shift the upper part of the scale of gradation into the over-exposed portion of the curve, but for some considerable distance the effect will not be appreciable to the eye, and it may, therefore, be taken as a practical working rule that if a given exposure is the least which can be given to get the deepest shadow detail represented by the smallest possible deposit on the plate, eight times that exposure will still give a perfectly satisfactory negative.

It is a matter of considerable interest to measure the amount of light reflected from the shadows of landscapes by means of such an instrument as the "Lumeter" referred to in the May number of "KNOWLEDGE." Experiments showed that in order to get a negative in which shadow detail was rendered by a minimum deposit on a plate of one hundred Watkins, it was necessary to give one-tenth of a second exposure at F8, if the light reflected from the shadows of the subject was of one hundred foot-candles intensity, and measurement of a number of subjects showed that in bright sunlight in the summer, the illumination in the shadows varied from about three hundred to fifty foot-candles, according to the depth of the shadow. The deduction drawn from such measurements appears to lead to a complete confirmation of the rule made by most experienced photographers, namely, that it is difficult, with a hand camera at any rate, to over-expose landscape subjects, and that a general rule when dealing with a landscape in which there is a considerable degree of contrast, is to give as much exposure as possible. It may be said, indeed, that one-tenth of a second at F8 will

rarely be found too long for a landscape subject with a close foreground.

When, however, there is no close foreground in the subject and little deep shadow, the range of contrast becomes very much less, it is quite possible for the intensity ratio between the darkest and lightest parts of an open landscape to be only one to three, and in this case it is absolutely necessary that care should be taken to keep on the side of under- rather than over-exposure, because, whereas with contrasty subjects the aim of the photographer must be to compress his scale in order to get it within the scale of the printing paper, with flat subjects having little range of contrast the object of the photographer must be to increase the contrast in order to get an effect pleasing to the eye, even though not necessarily a perfect rendering of the original. One effect of this desirability of increased exposure for increased contrast is found when such unusual subjects as tropical or alpine landscapes are photographed. In the tropics, with vertical sun and the absence of cloud, there is very little sky light to illuminate the shadows, and the shadows are consequently extremely deep and show much contrast with objects illuminated by the direct rays of the sun. This increase of contrast compensates almost completely for the greater intensity of illumination, and it is probable that a plate in the tropics should be given quite as much exposure for the same type of subject as would be required in England. Such photographs of the tropics as have come before my notice seem to bear this out very fully; they are nearly all under-exposed, in spite of the great intensity of illumination available. In the same way, the intensity of the light in the high alps is largely counter-balanced by the increased contrast due to the lack of sky illumination in the shadows, so that skilled alpine photographers almost always advise that plates in the high alps should be as fully exposed as if the camera were being used in England.

The relation between contrast and exposure does not seem at present to have been fully worked out; but there is no doubt in my mind that it is a subject which will well repay investigation, and that a discussion of practical photography, based on a number of experiments checked by direct measurement of contrast and intensity, would be of very considerable educational value for all classes of photographers.

PLATINOTYPE PRINTING. — Of all photographic printing processes, the Platinotype process is recognised to be that which gives results of the greatest beauty and the most absolute permanency. It is also an extremely quick process, requiring little time for manipulation, and, provided the exposure is correct, producing results of unvarying excellence. Unfortunately, however, it is not a printing-out process, and it is necessary to judge the depth of the printing from the appearance of the faint image produced by exposure to light, a matter which, while it presents no difficulties to the experienced worker who is continually doing it, is not so easily undertaken by one who only prints in Platinotype at rare intervals, and who is likely in the meantime to lose his sense of the necessary printing depth.

The use of mercury vapour lamps, however, both for lighting purposes and, as quartz lamps, for experimental work in scientific laboratories, puts within the reach of every possessor of such a lamp an almost perfect method of making platinotype prints. Mercury vapour lamps are almost always regulated either by hand resistances controlled by an ammeter or by iron wire ballast resistances enclosed in hydrogen, and consequently the intensity of illumination is very uniform and the prints can be exposed entirely by time. At twelve inches distance from a single Cooper-Hewitt tube taking three and a half amperes, the exposure for an ordinary negative will be about ten minutes, and a number of negatives can, of course, be placed side by side under the long tube at one time. A quartz lamp taking the same current at one hundred and ten volts would require about five minutes' exposure at twelve inches. This suggestion may be found useful by those workers who have a mercury vapour lamp available.

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

"SPHEROIDAL STATE." — When a little water is allowed to drop on to a hot plate of metal heated to 300°C about, it is well known that small spherical drops are formed which run about on the surface of the metal; these finally either diminish in bulk owing to formation of steam or collapse, produce a considerable quantity of steam and spread out on the hot surface if the latter cools to a sufficiently low temperature. The water is said to have gone into the "spheroidal state." The phenomena are well demonstrated in a lecture by means of a silver dish perforated with a hole in the bottom. The dish is heated by a burner, which is removed; a drop or two of water shaken on to the dish continues to move rapidly about on it until the metal has cooled sufficiently when the drop resumes its ordinary condition and can fall out through the small hole in the bottom of the dish. The phenomena can be shown very distinctly by an experiment of Sir James Dewar's. A drop of liquid air is allowed to fall on to small flat bottomed dishes containing such liquids as sulphuric acid, ethyl alcohol, or carbon tetrachloride. In each case the drop of liquid air assumes the spheroidal state and moves rapidly about on the surface of the liquid: but in the case of the more volatile liquids, such as ethyl alcohol and carbon tetrachloride, the drop is surrounded by a cloud of the condensed vapours of these liquids and, as it moves about, is followed by a cloudy tail. The drop impinging on to the walls of the vessel shoots off again as if possessed of perfect elasticity.

When the drop of water or liquid air first touches the hot surface there is considerable production of vapour, which acts as a cushion and prevents the liquid from coming into actual contact with the hot surface. The liquid is then free to assume the spherical drop form, which is due to the attraction of the inner molecules upon the molecules residing upon the outer skin of the liquid; the drop then tends to become spherical, so as to make the ratio of the surface to the volume as small as possible. Imagine a little water to have been allowed to fall on a hot plate; there will be a sudden production of steam, the water will disrupt into several distinct drops which, since they are not actually touching the metallic plate, will retain a spherical form, being buoyed up from the plate by the cushion of steam. Since the under surface of the liquid is heated most there will be more steam formed here, and more molecules will leave the drop at the point nearest the plate; there will be then a continual disturbance of the surface tension equilibrium along the surface of the drop, tending to cause a rotation within the drop. The vapour produced will tend to shoot out from under one side more than another, and so cause an initial movement in some particular direction, and give a definite direction to the rotation of the drop, which is maintained until some other disturbing influence is met with.

The motion of a particle of potassium or sodium when thrown on to water is very similar to that of a liquid dropped on to a sufficiently hot surface. The potassium causes a production of hydrogen and also a considerable quantity of heat; some of the water is vaporised and no doubt the action is carried on between the potassium and a thin jacket of steam, the hydrogen produced acting as the supporting jacket for the pea of potassium.

The motion of the drop, its rotation, its collapse and the curious palpitations it undergoes when rather too much is added to form the true spheroidal state, are very prettily illustrated by Sir James Dewar's experiment. The collapse of the drop is no doubt due to the actual contact of the drop with the hot surface, the surface tension equilibrium being then completely upset, causing the drop to wet the surface: a certain amount of heat is required to vaporise the liquid and the hot surface may be cooled locally to such an extent that insufficient steam is produced to support the drop and isolate it from the plate. The palpitation of a drop spread on the surface of a liquid is due to curious complicated changes in

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the surface tension due to gradual solution or to local cooling as the case may be. It is well shown by a drop of orthotoluidine containing paratoluidine.

Spherical drops of a liquid are sometimes formed during a distillation on the surface of the liquid which is being evaporated. This, however, is a different affair, the retention of the spherical form being probably due to some difference in composition and hence surface tension of the liquid and the drop.

Mr. Darling's experiments which have been recently described in "KNOWLEDGE" show most beautifully the gradual formation of a drop, which Professor Worthington has studied on a smaller scale photographically. Mr. Darling has devised a method of preserving a sphere of one liquid in another of equal density. A beaker is filled to two-thirds of its height with water at 22° C.: one hundred centimetres of a three per cent. solution of common salt are discharged at the bottom of the beaker, making thereby the lower layers of liquid slightly denser. A large tap funnel containing orthotoluidine at about 20° is inserted so that the stem of the funnel is seven centimetres or so from the bottom of the beaker. By slowly opening the tap the orthotoluidine will form a sphere of quite eight centimetres in diameter suspended within the water and can be shaken free from the stem.

Sulphur when heated on a glass slip, gathers itself into a flat bottomed drop and does not wet the glass, residing on it like a drop of mercury though not quite such a spherical drop could be formed. The drop will solidify in the same shape as it forms as a drop, but above 256° it begins to flatten and "wet" the surface of the glass. The description of these phenomena is due to Mr. W. A. D. Rudge.

In Mr. Darling's experiments on the formation of drops, as the large sphere of aniline hits the bottom of the beaker it flattens out into a disc-like form with rounded edges, in fact the aniline at the bottom of the beaker takes up a shape something like the small drop of sulphur in Mr. Rudge's experiment.

There are many phenomena of a curious and interesting nature connected with surface tension which it is well to call attention to from time to time as their explanations are as yet incompletely worked out.

ALLOTROPY.—Many substances can exist in more than one form; there are at least three distinct "allotropic" forms in which sulphur can occur, or two in which phosphorus exists, to take well-known examples. Thus sulphur exists in a rhombic crystalline form melting at 112·8° C., and in a monoclinic form melting somewhat higher, and being of a browner hue and insoluble in carbon bisulphide. Further there are other less distinct forms, such as colloidal sulphur formed by precipitation of sulphur from thiosulphates by strong acids, and so on, or plastic sulphur which is an extensible gummy brownish-yellow mass formed by suddenly cooling liquid sulphur, and is the latter in a supercooled state, which changes fairly rapidly into rhombic sulphur. A peculiar gummy sticky variety of plastic sulphur rather different in many respects to the other variety can be made by suddenly cooling liquid sulphur by pouring it into liquid air. This variety changes very rapidly, especially on touching it, into very yellow rhombic sulphur.

Much work on allotropy and the equilibrium between the different forms of substances under different conditions of temperature and pressure, has been done by Professor Cohen, of Leyden, and his collaborators. Smits has recently published a theory to explain the phenomenon of allotropy. In the liquid state a substance showing allotropy consists of two kinds of molecules; the number of one kind existing in presence of the other depends on the temperature, and, at any particular temperature, there exists an equilibrium between the two kinds. On rapid cooling, all of the one form does not change as the temperature falls, into the simpler form which is stable at the lower temperatures, because the equilibrium cannot keep pace with the change in temperature; solidification then occurs at a temperature differing from the solidification point of one of the molecular forms. Thus if rhombic sulphur be melted and allowed to cool to 90° C. so that equilibrium sets in at this temperature and then is *suddenly* cooled, the resulting sulphur melts at 110·9° C., or, if equilibrium occurs at 65° C. the melting point is 111·4° C. This points to the existence of two kinds of molecules. In the case of phosphorus which in the pure crystalline state, melts at 44° C. ± ·02° C., the melting point is considerably affected by previous heating at different temperatures, pointing to at least two different forms of molecules being present; the violet form, which is stable below 460° C., can be best accounted for by a discontinuity of the series of mixed crystals of the yellow and red forms. Mercury exists in only one modification, which is in agreement with its single molecular condition adduced from other considerations. Tin and many other elements exist in more than one form. The theory explains readily the phenomena of undercooling and superheating such as occur during rapid cooling and heating. Having mentioned superheating it is interesting to note that the vapour pressure curve of solid bromine, obtained recently by Cuthbertson by optical means, shows evidence of superheating of this solid, the vapour pressure being greater than that of the liquid above the real melting point of the solid.

LIQUID HELIUM.—Kamerlingh Onnes has been making further experiments with liquid helium; he finds the density at 4·29° from the absolute zero (−273·12°C.) to be 0·122 and the liquid appears to possess a maximum density at 2·2°. He has also found that mercury when exposed to a temperature of 3° absolute, such as is produced by liquid helium boiling under reduced pressure, has an exceedingly great electrical conductivity: ten million times greater than at 0·C.; which is rather a surprising result, considering that from the temperature coefficient one would expect a resistance of 40 ohms, instead of 3×10^{-6} ohms! Other properties, such as magnetic susceptibility, are considerably altered by these very low temperatures, though the electrical resistance of other metals, such as silver, lead, eureka, and so on, is not modified to anything like the same amount as that of mercury. Further experiments to elicit the cause of the phenomena will be awaited with interest.

URANIUM.—The name of Becquerel has been associated with the study of phosphorescence for generations. M. J. Becquerel has been studying for some time the effect of low temperatures on phosphorescence which, in general, causes an increase in the duration of the phosphorescence. However, he finds that the low temperature does not affect the duration of the phosphorescence of uranium nitrate and sulphate—the most phosphorescent of uranium salts; while the acetate, tartate, and so on, show much longer persistence of phosphorescence at low temperatures. Uranium nitrate exhibits marked "triboluminescence"; if a bottle of the nitrate be shaken in the dark, flashes of light will be seen; this is due to cleavage of the crystals accompanied probably by minute electrical discharges which excite the crystals to phosphoresce. It is a very different phenomenon to the sparks of uranium obtained by shaking a bottle of metallic uranium. The latter is a "pyrophoric" property; the uranium particles which are struck off in the shaking actually burn in the air, owing to the avidity with which uranium combines with oxygen; the same phenomenon is found with cerium and iron. I have been able to run a petrol engine using these sparks as the igniting agent for the explosive mixture, but I do not think the method a practical one owing to the injury to the cylinder walls. The triboluminescence of uranium salts is a very different affair from the pyrophoric property of the metal; the triboluminescence is unaffected by an atmosphere of hydrogen, while the pyrophory no longer occurs.

Pitchblende is the main ore from which uranium is obtained; it is also the chief source of radium. It is noteworthy that H. Poole has found that the evolution of heat by a mass of pitchblende is greater than would be expected from its radium content, and the fact that radium generates one hundred and ten calories per hour. The difference between the observed heat generation and the calculated

appears greater than would be accounted for by the presence of other radio-active substances such as uranium, thorium and actinium, and might perhaps be due to the more complete absorption of the radium rays in the mass of the pitchblende, than occurs when a measurement of the heat production of pure radium is made.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

THE AWAKENING HEDGEHOG!—When a hibernating hedgehog awakens it rapidly warms itself up. Whether this comes about automatically, or whether it is due to the awakening animal "pulling itself together" seems to be a moot point. The fact is that the animal rapidly warms itself up. The chemistry of this, according to Tanzo Yoshida and Ernst Weinland, is a rapid combustion of glycogen along with a small or moderate quantity of fat. There seems no doubt that the important fuel that so rapidly makes the fire of life burn up is glycogen: the fat is only subsidiary. It must be noticed that in the hedgehog the awakening and the warming-up are two distinct, though associated, processes; for the animal may be wide awake at a lower temperature.

VARIATIONS IN FOWLS' COMBS.—Poultry-breeders know when a hen is going to begin to lay by a rapid and marked increase in the size of the comb. Mr. Geoffrey Smith has shown that this correspondence is exact both in young and adult hens. There may be an increase of 130 per cent. within three weeks, and this does not correspond with a general increase in weight, though the latter usually precedes it. After the laying period, there is a decrease in the comb. The cock's comb does not exhibit these marked fluctuations.

The increase is due to a fatty infiltration of the central connective-tissue core of the comb, and the explanation of the infiltration is to be found in the fact that at the egg-laying periods the blood becomes charged with fatty material which is conveyed to the ovary for the formation of yolk, the excess being deposited in the comb, and probably in other situations. Mr. Geoffrey Smith compares this with what occurs in a spider-crab parasitised by *Sacculina*; the *Sacculina* "forces the crabs to elaborate yolk-material;" this circulates in the blood; it should be stored in the ovaries, but there are none, because of the inhibiting influence of the *Sacculina*, the yolk material; it nevertheless acts as the stimulus for the development of the adult female secondary sexual characters.

HORNBILL'S STOMACH.—Everyone knows of the strange bag of indigestible debris which hornbills periodically eject, but there is a lack of precision in the statements that have been made. An interesting recent contribution by H. C. Curl shows that the deciduous membrane in the great Philippine hornbill, *Hydrocorax hydrocorax*, studied outside the breeding season, is a tough, homogeneous sac formed of colloid material secreted by the glands of the stomach wall.

MOSQUITO SUCKED BY MIDGE.—F. H. Gravely reports finding in the Sunderbunds a small Chironomid fly (*Culicoides*) with its proboscis well-embedded in the abdomen of a mosquito (*Myzomyia rossii*) and evidently imbibing nourishment from it. Probably the *Culicoides* sucks mammalian blood, and was taking it second-hand from the mosquito.

A FRESHWATER RHIZOCEPHALON.—Dr. Nelson Annandale, Superintendent of the Indian Museum, describes a very interesting animal, which he calls *Sesarmaxenos monticola* g. et sp. n. It is somewhat like the well-known *Sacculina* that occurs beneath the abdomen in shore crabs, and it occurred in a similar position on a fresh water crab, *Sesarma thelxinoe*, in a jungle stream in the Andamans, seven hundred feet above sea level. This is the only known freshwater Rhizocephalon, and only the one specimen has been found.

CAMBRIAN SEA-CUCUMBERS.—From the Middle Cambrian, British Columbia, Charles D. Walcott describes the first Holothuroids found as fossils. Some isolated calcareous plates have been previously recorded, but now we have entire animals,—unluckily without any calcareous plates. The most remarkable type, which the discoverer calls *Eldonia*, and describes as free-swimming, has some suggestion of a medusa about it, but Dr. Walcott has given careful consideration to that possibility. Trilobites, Phyllopods, and Medusae were found in the near vicinity. Again, we have striking evidence that there must have been great steps in animal evolution in Pre-Cambrian and early Cambrian ages.

NOTES ON THE AFRICAN FRESHWATER MEDUSOID *LIMNOCNIDA*.—Charles L. Boulenger has some interesting notes on this medusoid from Lake Tanganyika. The stinging-cells of the tentacles are not developed *in situ*, but in the ectoderm of the "nettle-ring," a thickening along the margin of the umbrella. This ring is a factory and a storage-place of the stinging-cells and they migrate thence to the tentacular batteries. There is a well-developed double nerve-ring at the base of the velum, similar in most respects to that of *Limnocodium*, and of other medusoids. Mr. Boulenger shows that the manubrium is undoubtedly functional as a digestive organ. The development of the medusoid buds presents several interesting features, some of which are undoubtedly primitive.

A REMARKABLE SPONGE.—Mr. R. Kirkpatrick, of the British Museum, gives a full and finely illustrated account of *Merlia normani*, a sponge with a siliceous and calcareous skeleton. It was found by Canon Norman, and subsequently by Mr. Kirkpatrick, in sixty to ninety fathoms, off Madeira and Porto Santo. The sponge character of the organism has been called in question mainly, if not wholly, on *a priori* grounds, but the author has examined five hundred specimens. Dr. Weltner supposes that the calcareous structure is that of an unknown organism in which a siliceous sponge has settled. "If this be so," Mr. Kirkpatrick answers, "the said organism has preserved its incognito in a marvellous manner." But we do not follow his reasoning when he says: "If, as I believe, *Merlia* is a siliceous sponge which has taken to forming a calcareous skeleton, then this sponge furnishes a good example of the hereditary transmission of an acquired character." Taking to forming lime is not an "acquired character" in the technical sense; it was probably a constitutional variation.

THE BRITISH ASSOCIATION.

THIS year's meeting will open on Wednesday, August 30th, at Portsmouth, under the presidency of Professor Sir William Ramsay, who will give his address in the Town Hall at 8.30 p.m. *The Hampshire Post* estimates that between fifteen hundred and two thousand members will be present. On Friday, September 1st, at 8.30 p.m., the first Evening Discourse will be delivered by Dr. Leonard Hill, F.R.S., on "The Physiology of Submarine Work." On Monday, September 4th, at 8.30 p.m., the second Evening Discourse will be delivered by Professor A. C. Seward, M.A., F.R.S., on "Links with the Past in the Plant World."

Of recent years there has been an outcry against the papers being made so technical that local members, who are not specialists, cannot appreciate them. It has been customary for Section D (Zoölogy) to arrange a popular lecture, and this year two appear in the programme, namely, one on "Fairy Flies," by Mr. Fred Enock, and the other on "Fossil Reptiles," by Dr. Andrews. "Rain" will be considered by Dr. H. R. Mill in his lecture to the operative classes, and some very attractive excursions have been arranged to Arundel Castle, to the New Forest, and to the Isle of Wight.

XUM

THE FACE OF THE SKY FOR SEPTEMBER.

By W. SHACKLETON, F.R.A.S., A.R.C.Sc.

THE SUN.—On the 1st the Sun rises at 5.13 and sets at 6.48; on the 30th he rises at 5.58 and sets at 5.43. The Sun enters the sign of Libra on the 24th at 4 a.m., when autumn commences. The equation of time is negligible on the 1st and 2nd, hence these dates are convenient for the adjustment of sun-dials, as only the longitude correction is needed. Sun-spots and faculae are very sparse, although occasionally a spotlet or a few faculic markings may be seen. The positions of the Sun's axis, centre of the disc, and heliographic longitude of the centre are given in the following table :—

Date.	Axis inclined from N. point.	Centre of Disc N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Sept. 3 ...	21° 34′E	7° 14′	299° 20′
,, 8 ...	22° 44′E	7° 15′	233° 18′
,, 13 ...	23° 44′E	7° 13′	167° 17′
,, 18 ...	24° 37′E	7° 8′	101° 16′
,, 23 ...	25° 19′E	7° 1′	35° 17′
,, 28 ...	25° 51′E	6° 49′	329° 17′
Oct. 3 .	26° 13′E	6° 35′	263° 19′
,, 8 ...	26° 25′E	5° 18′	197° 20′

A suitable diagram, for this period, for the projection of the solar disc is shown on page 310 of last month's issue.

THE MOON :—

Date.	Phases.	H. M.
Sept. 8 ...	○ Full Moon	3 57 p.m.
,, 15 ...	☾ Last Quarter	5 51 p.m.
,, 22 ...	● New Moon	2 37 p.m.
,, 30 ...	☽ First Quarter	11 8 a.m.
Oct. 8 ...	○ Full Moon	4 11 a.m.
Sept. 2 ...	Apogee	7 18 a.m.
,, 17 ...	Perigee	6 0 a.m.
,, 30 ...	Apogee	2 30 a.m.

OCCULTATIONS.—The only naked eye star occulted during the present month and visible from Greenwich, is the 5½ magnitude star 43 Ophiuchi. The occultation occurs on September 1st, disappearance being at 7.58 p.m., and re-appearance at 8.4 p.m.

THE PLANETS.

MERCURY :—

Date.	Right Ascension.	Declination.
	h. m.	
Aug. 30 ...	11 30	S 1° 28′
Sept. 9 ...	11 3	N 2° 14′
,, 19 ...	10 46	7° 16′
,, 29 ...	11 19	N 6° 6′
Oct. 9 ..	12 20	S 0° 7′

Mercury is in inferior conjunction with the Sun on the 9th. After this date the planet is a morning star in Leo and is at greatest westerly elongation of 17° 52′ on the 25th, on which date he rises at 4 a.m., or nearly two hours in advance of the Sun. The elongation is thus a somewhat favourable one for seeing the planet.

VENUS :—

Date.	Right Ascension.	Declination.
	h. m.	
Aug. 30 ...	11 45	S 6° 14′
Sept. 9 ...	11 28	5° 53′
,, 19 ...	11 7	3° 30′
,, 29 ...	10 52	S 0° 26′
Oct. 9 ...	10 52	N 1° 50′

Venus is in inferior conjunction with the Sun on September 15th, and throughout the month is unobservable, as she appears too near the Sun.

MARS :—

Date.	Right Ascension.	Declination.
	h. m.	
Aug. 30 ...	3 41	N 17° 42′
Sept 9 ..	4 0	18° 49′
,, 19 ...	4 16	19° 44′
,, 29 ...	4 28	20° 28′
Oct. 9 ...	4 36	N 21° 3′

Mars is an evening star, rising N.E. by East at 9.30 p.m., on the 1st, and at 8 p.m. on the 30th. The planet appears between Aldebaran and the Pleiades, somewhat nearer the former.

The planet is becoming more favourably placed for observation and is increasing in brightness, the apparent diameter of the disc increasing from 11″·4 to 14″·0 during September.

As seen in the telescope the planet appears gibbous, 1″·6 of the disc being unilluminated. The south polar cap is visible and appears fairly bright; but other markings are difficult to delineate in telescopes of three or four inches aperture, even if powers of two hundred or three hundred be used.

JUPITER :—

Date.	Right Ascension.	Declination.
	h. m.	
Aug. 30 ...	14 29	S 13° 44′
Sept. 9 ...	14 35	14° 15′
,, 19 ...	14 42	14° 48′
,, 29 ...	14 49	15° 23′
Oct. 9 ...	14 57	S 15° 59′

Jupiter is an evening star setting W.S.W. at 8.45 p.m., on the 1st and at 7 p.m. on the 30th. The planet is very little observable as he is rather low down at sunset, and is soon lost to view in the evening haze.

No satellite phenomena are observable, as the planet appears in too bright a portion of the sky when any of the transits or eclipses occur.

The configurations of the Satellites as seen in an inverting telescope and observing at 7 p.m. are as follows :—

XUM

Day.	West.	East.	Day.	West.	East.
1	2 ○	134	16	231 ○	4
2	32 ○	4 ●1	17	3 ⊙	24
3	31 ○	42	18	3 ○	124
4	34 ○	21	19	213 ○	4
5	421 ○	3	20	2 ○$_4$	13
6	4 ○	13 ●2	21	41 ○	23
7	41 ○	23	22	42 ○	13
8	42 ○	13	23	4213 ○	
9	4$\frac{2}{3}$1 ○		24	43 ○	12
10	$\frac{1}{3}$1 ○	2	25	43 ○	2 ●1
11	34 ○	$\frac{1}{2}$	26	4231 ○	
12	213 ○	4	27	42 ○	13
13	○	134 ●2	28	14 ○	23
14	1 ○	234	29	⊙ $\frac{1}{1}$	3
15	2 ○	134	30	21 ⊙	4

The circle (○) represents Jupiter; ⊙ signifies that the Satellite is on the disc; ● signifies that the Satellite is behind the disc or in the shadow. The numbers are the numbers of the Satellites.

SATURN:—

Date.	Right Ascension.	Declination.
	h. m.	
Sept. 1 ...	3 14	N 15° 29′
,, 16 ...	3 13	15° 23′
Oct. 1 ...	3 11	N 15° 12′

Saturn rises in the E.N.E. at 9.10 p.m. on September 1st, and at 7.10 p.m. October 1st. The planet appears as a conspicuous object in the evening sky looking East, and is situated about midway between Aldebaran and α Arietis, where he may be observed shining as a bright star free from scintillation, but with a peculiar lustre which has given it the name of the Leaden Planet. The telescope view of the planet with his rings is superb, and even when other objects are difficult to define, Saturn exhibits crisp detail, well repaying observation. The ring is visible in quite small telescopes, such as an ordinary good deer-stalker, with a high power eyepiece, and in a good three-inch telescope the ring is visible with a power of about fifty, and the belts on the planet's surface with a power of about eighty; using higher powers the division in the ring may be seen. The diameter of the outer major and minor axes of the ring system are respectively 45″ and 17″, so that the ring appears well open, being inclined to our line of vision at an angle of 22°, the southern surface being visible.

The planet has eight satellites; of these, Titan, (mag. 8·5) can be observed with a good objective of two inches aperture, Iapetus (mag. 9·12) may be seen at his westerly elongations with a telescope of three inches aperture, which is also sufficent to show Rhea (mag. 9·5) and Tethys (mag. 10) whilst Dione (mag. 10·5) requires an aperture of four inches. The three other satellites require larger telescopes, since their magnitude is less than twelve.

URANUS:—

Date.	Right Ascension.	Declination.
	h. m. s.	
Sept. 1 ...	19 51 55	S 21° 32′ 0″
Oct. 1 ...	19 49 57	S 21° 36′ 39″

Uranus though rather low down in the sky, is fairly well placed for observation during the early evening, and is due South shortly after dusk. The planet is situated in Capricorn in a part of the sky devoid of good reference stars, though the star σ Capricorni is about 2° to the N.E. The planet is at the stationary point on the 6th October, after which his motion is direct or Easterly.

Uranus can just be discerned with the naked eye on clear nights, but the slightest optical aid is sufficient to make the planet clearly visible.

The planet is in conjunction with the moon at 4.37 p.m. on the 4th, Uranus being 4½° to the north.

NEPTUNE:—

Date.	Right Ascension.	Declination.
	h. m. s.	
Sept. 1 ...	7 38 40	N 20° 56′ 10″
Oct. 1 ...	7 41 26	N 20° 49′ 23″

Neptune does not rise till midnight on the 12th; thus for all practical purposes the planet is unobservable.

METEORS:—

Date.	Radiant. R.A.	Radiant. Dec.	—
Sept. 3-8...	353°	N. 39°	υ Andromedids. Very swift.
,, 5-15...	62°	N. 37°	ε Perseids. Swift, bright streaks.
,, 21-27...	87°	N. 43°	β Aurigids. Very swift.

Minima of Algol occur on the 2nd at 7 p.m., and on the 22nd at 8.30 p.m.

The period is $2^d\ 20^h\ 49^m$, from which other minima may be calculated.

TELESCOPIC OBJECTS:—

DOUBLE STARS.—ζ Ursae Majoris XIII.^{h} 20^m, N. 55° 23′, mags. 2. 4; separation, 14″4.

ζ Aquarii XXII.^{h} 24^m, S. 0° 32′, mags. 4, 4; separation, 2″·9. Both components are yellowish.

β Cygni XIX.^{h} 27^m, N. 27° 46′, mags. 3, 5; separation, 34″. The brighter component is yellow, the other blue; very easy double in small telescopes with a power of 20.

Cluster (M 11) in Aquila or Antinous. R.A. $18^h\ 46^m$; Dec. S. 6° 23′. Very pretty object for three or four-inch telescopes; it is an easily resolvable fan-shaped cluster, with an eighth magnitude star in apex and an open pair of the same magnitude just outside it.

THE BRENT VALLEY BIRD SANCTUARY.

A MOST successful season has been experienced in the Bird Sanctuary, and even now there is still (August 28th) a bullfinch's nest containing eggs. It has been suggested by Mr. Robert Read, M.B.O.U., that it may have been built by a pair of this year's birds, and should they prove to be poorly coloured it will be additional evidence in favour of the supposition being correct. The nesting boxes made from logs similar to those illustrated and described in the April number of "KNOWLEDGE," which were tested, were with very few exceptions tenanted, though many were put in quite exposed situations. A large number of these boxes which were sold were also used to good effect in the majority of cases, and the profits have been applied to the upkeep of the Sanctuary. The wood is interesting at all times of the year, and during the past week the following birds have been seen: Kestrels, green and greater spotted woodpeckers, nightjar, kingfisher and turtle dove. The Honorary Secretary of the Committee is Mrs. Wilfred Mark Webb, and her address is "Odstock," Hanwell, London, W.

XUM

THE NEW ASTRONOMY.

I. THE STORY OF NOVA PERSEI.

By PROFESSOR A. W. BICKERTON.

As the twentieth century dawned, an astronomical event occurred that had not had its equal in the history of celestial observation for some three hundred years. A brilliant temporary star suddenly blazed out in the Northern hemisphere, and as these evanescent flashes are called Nova or New Stars, this star was called the New Star of the New Century, and because it was in the constellation of Perseus, it was called Nova Persei.

Nothing in the whole realm of Nature is so wonderful as this event, the bursting out of a giant sun, its then increasing with amazing rapidity, until it is sometimes many scores of thousands of times the brilliancy of the magnificent luminary that keeps the earth in its orbit.

And no other celestial event has so fascinated the minds of men, and drawn them to study the heavens, as these exploding suns. It was one of these brilliant portents that caused Hipparchus to draw up his historic list of the stars. It was another that caused Tycho Brahé to leave the lamps and furnaces of his laboratory, and come out into the open to study the celestial vault and make his wonderful measurement of the places of the planets. It was a temporary star that drew Galileo into that war of words and wonder of achievement and ideas that cost him so much, and also made him teach the Copernican doctrine of the moving earth.

And again this year, the new star in the constellation Lacerta, discovered by Mr. Espin, has caused an immense amount of discussion not merely amongst the learned societies, but even in the popular newspapers all over the world. It is commonly thought that the star of Bethlehem was a new one.

Speaking of these flashing bodies the late Professor Newcomb says:—"The so-called new stars which blaze forth from time to time, offer to our sight the most astounding phenomena ever presented to the physical philosopher." Carl Snyder says:—"Could they be closely regarded, the blazing up of these novae would doubtless be, in mere extent, the most impressive spectacle the realms of Nature afford." That very able astronomer, the late Miss Agnes Clarke says:—"What they were, what they are, what they become, are all difficult questions to answer. But the crux of the whole problem concerns the manner of their vivification. A body previously inert is transformed wellnigh instantaneously into a radiative centre of immeasurable intensity. How is the change effected?"

No human being is capable of conceiving the vastness of this phenomena. To us, the earth is an immense body; we know it weighs more than six thousand million of million of million of tons. Our Sun is more than a million times the size of the Earth, and those vast globes of fire must often be many scores of thousands of times the volume of the Sun. Yet Nova Persei rose from invisibility to its maximum in less than forty-eight hours, and in a few months was again invisible to the naked eye. The stupendous nature of the phenomena and their evanescent character constitutes their chief wonder. Newcombe speaks of their impenetrable mystery. He says:—"The cause of these outbursts is a question of transcendent interest, the answer to which science has not up to the present time been able to offer any suggestions not open to question." Miss Agnes Clarke says:—"That even the most promising explanation is not merely unscientific, but outrageous to common sense."

There are an immense number of explanatory suggestions in various books on astronomy, all of which are absolutely puerile when we regard the insufficiency of energy to explain the phenomena. The question then occurs, Can any solution to their mystery be suggested? Is there any storehouse of energy that can be laid under contribution to supply fuel for so stupendous a conflagration? And the answer is clear and explicit. There is.

In the collisions of suns, we have a sufficiency of energy to account for the whole phenomena. Hence a detailed study of the phenomena of solar collisions offers the most promising ground for the solution of the mystery of these immeasurable conflagrations.

Impact, a Law of Nature.

A very superficial study shows us that solar collisions cannot be looked upon as accidental, chance, or mere random occurrences. Mutual attraction, and many other agencies, something like a dozen in all, have been investigated, and the conclusion is forced upon us that the number of solar impacts that must be produced by these many agents are hundreds of thousands of times more numerous than mere random encounters. The next thing that shows itself in our investigations is, that not one of all these collisions that are brought about by attraction, and so on, can be a direct centre-to-centre impact. The bodies must move in curved orbits, and hence the collisions so produced must be of a tangential or grazing character.

It was also shown that the extreme velocities produced by attraction in all cases of colliding suns must be of the order of hundreds of miles a second.

That is, if trains possessed this velocity, their collision would have an energy hundreds of millions of times greater than that of colliding express trains. It cannot be imagined that a slight graze of suns passing one another with these speeds will stop them. The portion actually in one another's paths will be shorn away, and the torn suns will proceed on their journey with orbits modified by the attraction of the newly-formed third star. The phenomena of these torn suns may be of the most varied character. They explain many of the characteristics of the wonder stars and double stars of the heavens. In telling the story of Nova Persei they do not greatly concern us, but must be referred to when we study the wonderful spread of light that flashed through the previously existing nebula, at whose centre Nova Persei appeared.

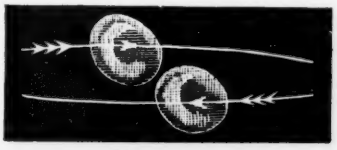

FIGURE 1.
A pair of Stars distorted and coming into impact.

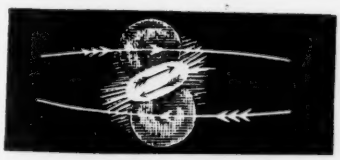

FIGURE 2.
A pair of Stars in impact.

FIGURE 3.
The Stars passing out of impact, and the formation of a third body.

THE THEORY OF THE THIRD BODY.

It is the properties of the coalesced portion torn from the two passing suns, that correspond with, and explain in the minutest detail, every one of the multifarious observations that astronomers have made of Nova Persei. The deductions that explain these observations were published fully a score of years before the wondrous star appeared.

The accompanying Figures (1–5) have been photographed from diagrams made and published more than thirty years ago, and show kinematically the progress of an impact during its first few hours. Figure 4 is probably the most instructive of the whole, because it shows not merely the form and motion of the third body, but also the distribution of the adherent heated matter, clinging to the two retreating suns.

The most important characteristic of this third body is its stupendous, its absolutely abnormal and explosive energy. Ritter and myself have shown that the energy of the critical velocity of a pair of similar completely colliding gaseous suns, is exactly one half of that necessary to produce an infinitely diffused nebula. It must be remembered that similar chemical elements, colliding with similar velocities, produce the same temperature, and hence, however small the portion torn away, if it be of the same composition, whether small or large, it will have the same temperature as though there were a complete collision. Thus, contrasting a complete collision with a graze of one-tenth, in the one case we have the whole matter heated to a certain temperature and in the other case, one-tenth is heated to the same temperature. In the third body there is one tenth the mass, and one tenth the heat; hence the temperature is the same as with complete collision. The speed of a particle possessing sufficient power to enable it to escape completely from a body, is called the critical velocity. Now the critical velocity depends to a large extent on the mass of the attracting body. Thus a body having a velocity of one-and-a-half-miles a second could escape the moon, a particle with a speed of seven miles a second could escape the earth: whilst an asteroid requires to have a velocity much over three hundred miles a second to entirely escape the sun. Consequently with two bodies of the same temperature and different mass the molecules may move fast enough to get entirely free from the body of small mass, and be retained by the body of large mass. The third body is a small mass at an exceedingly high temperature, as high as if the whole of the two suns had collided, and hence, if it be only one-tenth of the mass of a sun formed by complete collision, this third star possesses many times more energy than is necessary to make it explode.

The new star formed by a grazing collision of suns, being explosively hot, at once begins to expand at something like a million miles an hour. When first formed it is a body of astonishing brilliancy, and as this vast bonfire grows it becomes more and more brilliant. The maximum of brilliancy is quickly reached, but the velocity of the particles has scarcely diminished at all, and so they go diffusing in space, until the mass forms a rare nebula; the luminosity gradually diminishing from maximum until the star becomes invisible to the naked eye. The great energy of the molecules is not equally distributed amongst the elements, for it is a property of molecules that when at the same temperature each

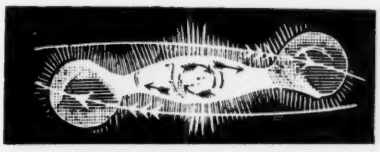

FIGURE 4.
Showing entanglement of matter in each body.

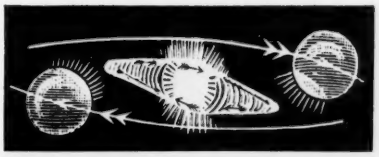

FIGURE 5.
Two variables and a temporary Star.

atom possesses the same energy. An atom of lead weighs two hundred and seven times as much as an atom of hydrogen, and yet when both the atoms are at the same temperature each has the same energy ; one has great mass, the other great velocity. Immediately after the collision all the elements have the same velocity, that is at the moment of the formation of the third body, lead is excessively hot, and hydrogen much cooler. As equality of temperature is gained, the hydrogen robs the heavier elements of their energy, and may attain an extraordinary velocity. The velocity of hydrogen actually recorded in the case of Nova Persei, was fully a thousand miles a second. In this way the light gases escape away from the heavier ones, and leave them behind, the light elements forming vast ensphering shells constantly expanding outwards. The heavy gases tend to form an intensely brilliant nucleus, that has not sufficient energy for complete dissipation. Hence there is a limit to its expansion. But the outward momentum of the particles will carry them beyond the limit of equilibrium. When they come to rest, gravitation will cause the mass to shrink again; as it shrinks it will increase in brilliancy; but again the momentum of the molecules will carry them past the position of equilibrium, and this oscillation may go on for an indefinite number of times, until an approximate balance is obtained. This balance is not one of rest; for, as will be shown immediately, the third body must be in a rapid state of rotation, due to the conflicting forces of impact. Let us examine the light curve of the third body and we shall see that the curve deduced by dynamical reasoning (see Figure 9) is absolutely similar in every respect to the curve drawn at South Kensington, from actual observation of Nova Persei.

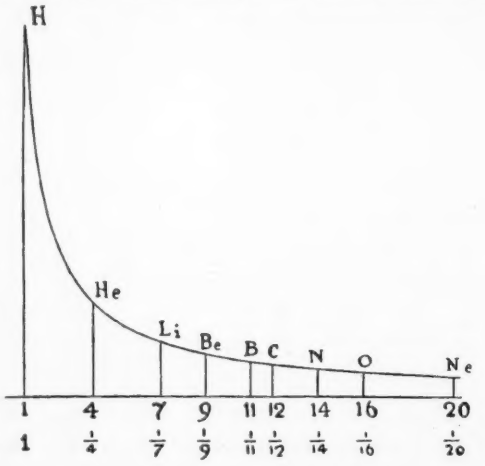

FIGURE 6. Atomic Kinetol.

Calculation shows the impact, that is, the initial explosion, takes an hour, and the body is at once of transcendent brilliancy. It then expands with extreme rapidity, hence the light curve to commence with is almost vertical. It increases with great speed for a short time, remains for a while approximately at the same height, and then begins to fall, falling much more slowly than it rose. Presently contraction sets in, during which time the curve rises, because, under the influence of pressure, the light becomes more intense. Then again expansion ensues with lessened luminosity, to be again followed with another period of compression, with increased light. And so the curve continues to oscillate for a period that is dependent on a vast number of special circumstances, which must vary with each nova. In the case of Nova Persei the oscillations were very long sustained.

THE FORM OF THE THIRD BODY AND ITS ROTATION.

It will readily be seen that the light gases on the outside of the two impacting suns will be the first to meet, hence, as the material crowds in upon itself, this light material will, when the body is first formed, be at its centre. As we examine the effect of the collision on each of the two suns, we see that it must form a long valley in each ; this valley gradually becoming deeper and deeper. As the two torn suns leave each other, the material deep down in its mass will be dragged along, and much of it will be left adhering to the end of the vast valley, that has been cut in each sun. As the suns leave one another the new third body stretches out into the spindle form, and the distribution of material will now be that the lightest elements will be at its centre, the somewhat heavier ones will surround these light gases, whilst the heaviest portion of the third body will be at the ends of the spindle. These ends may consist of elements whose atomic weight will seldom be less than forty or more than seventy. The reason it will not contain very heavy elements is because, for various reasons, it can be shown that when there is an exceedingly deep graze the three bodies do not part company, but form a rapidly rotating mass, that is probably what is known as a Wolf-Rayet star. I have named such a deep collision a case of Whirling Coalescence. Owing to this fact of the difference of the quantity of material meeting on opposite sides, the third star is set rotating. The mountainous mass of material left on each of the torn suns also in these scarred globes produces rotation. These complex phenomena explain many characteristics of variable stars, not however of interest in connection with Nova Persei. This peculiar property possessed by the light gases, of sorting themselves into concentric shells according to their speeds, we have called Atom Sorting or Selective Molecular Escape. The principle here introduced was fully studied in 1878, and the late Dr. Johnstone Stoney devoted a considerable amount of time to showing its influence with regard to hydrogen and other light elements, in our atmosphere.

The principle is of supreme importance in connection with the impact theory of cosmic evolution, and must be clearly understood. To

simplify the conception a new dynamical term is necessary; it is an expression for the amount of energy that is possessed by a unit mass of any body. The necessity for, and the meaning of, the term is fully discussed on pages 15, 16 and 17 of "The Birth of Worlds and Systems," in Harper's Library of Living Thought. The new term is Kinetol. The kinetol possessed by monatomic molecules of the different elements when at the same temperature, is inversely as their atomic weight. Thus, the kinetol of hydrogen being taken as unity, the kinetol of helium would be one-fourth, of oxygen would be one-sixteenth and lead one two-hundredth-and-seventh part. The diagram (see Figure 6) represents the atomic kinetol of some of the lighter elements. Popularly speaking, kinetol is the power to escape from a force.

FIGURE 7.

Part of a spectrum of Nova Persei taken on the 5th of March, 1901, at South Kensington, and reproduced by kind permission of Sir Norman Lockyer, from his paper in the "Proceedings of the Royal Society," Volume 68.

The spectra of the stars shows that hydrogen is altogether the most prominent element that exhibits itself, and consequently hydrogen is the element which is most important to study.

It is probable that in almost all grazing impacts hydrogen will possess from fifty to a hundred times the kinetol necessary for it to completely escape the attraction of the third body. The whole work that it will do in completely escaping will not lessen its velocity one per cent. This fact furnishes a complete explanation of the phenomenon that has proved so puzzling in connection with the retention of velocity as shown by the spectrum of hydrogen in Nova Persei and other new stars.

THE SERIES OF SPECTRA OF THE THIRD BODY.

It has already been shown how exactly similar are the deduced light curves of the third body and the observed light curve of Nova Persei. The contrasted series of spectra are of much greater complexity, yet show the same actual identity of character. On the one hand, there is not a single observation in all the spectrograms that has not been dynamically deduced. And, on the other hand, although the observation of no single observatory seems to satisfy all the deductions made, yet, taking the whole world, the observations leave but little to be discovered. There are still a few minor deductions remaining to be confirmed by observation. Let us examine the salient characteristic of the spectra that must be produced by the successive phenomena of the third body. Clearly at first a mass so hot and under such stupendous pressure will give a continuous spectrum. Presently, as hydrogen escapes from the interior and forms a close atmosphere, the continuous spectrum will be crossed with black absorption lines of hydrogen.

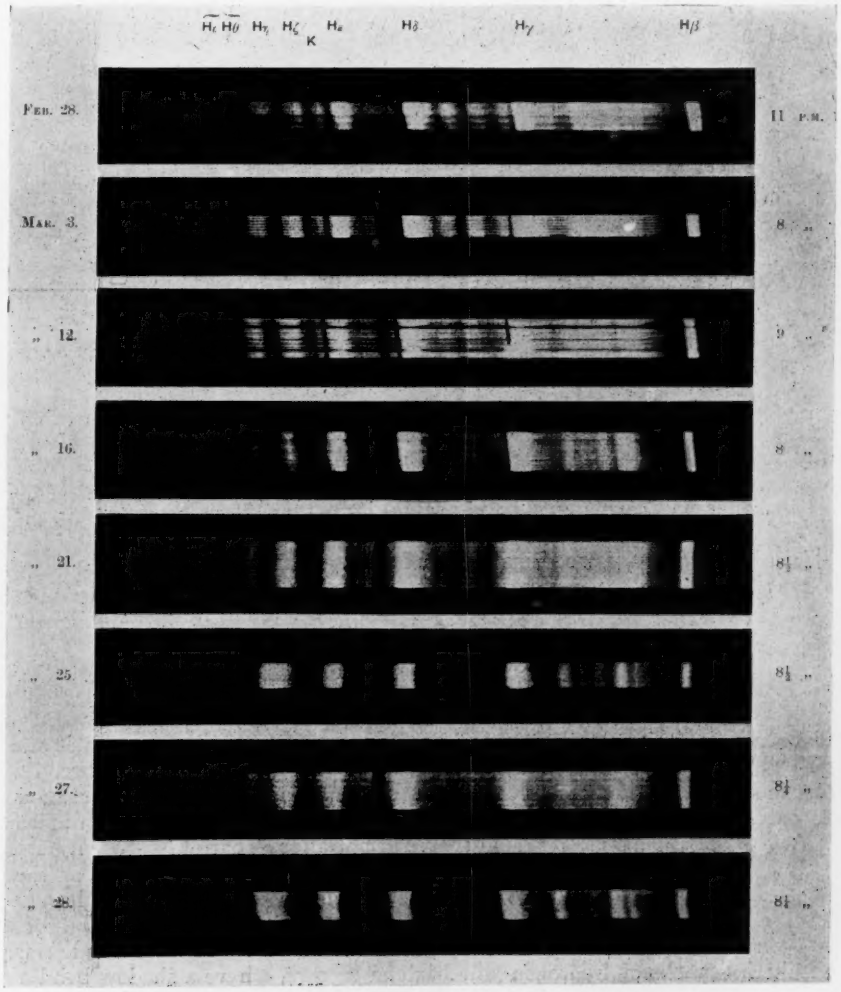

FIGURE 8.

Photographs of the Spectrum of Nova Persei, 1901, taken at Stonyhurst College Observatory, and copied from a Plate in "KNOWLEDGE" for January, 1902.

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Soon, however, the hydrogen escapes and becomes free, and forms an ensphering shell many diameters of that of the brilliant nucleus of heavy matter. This brilliant gas shell, as it is expanding in all directions, is moving at every angle to the line of sight, both from and towards us. Hence what would, were the gas in a fixed position, be a bright line, becomes an exceedingly broad band, indicating at its extreme edges atomic velocities of a thousand miles away from and towards us. Hence we now have a continuous spectrum covered with brilliant bands of the hydrogen series. But the part of the shell of hydrogen that is immediately in front of the brilliant nucleus, must absorb its isochromatic rays and produce reversion. The hydrogen coming our way has its wave length shortened, that is, displaced towards the violet; consequently each one of these bright bands will have a dark band edging it, on the side towards the violet. Many observatories all over the world obtained spectrograms of Nova Persei, when it was exhibiting this spectrum. Those of South Kensington and Stonyhurst were both singularly perfect, and examples are given here (see Figures 7 and 8), and it will be seen that observation exactly corresponds with deduction. The next deduced change in the spectrum of the third body will be that as the speed of expansion of the ensphering shell does not appreciably diminish, the ratio of the portion of the sphere that is in front of the absorption nucleus must get to be extremely small. Consequently the dark lines edging the bright bands, although they will not alter their position, will become exceedingly thin and hair like. Later on, the tenuity of the gas shell will be so extreme that it will possess no absorbing power and will disappear. A little later on the vast ensphering shells of hydrogen will become so rare, that molecular encounter will diminish so much that the lessened luminosity will cease to photograph itself, and so the bright bands will die out. The atmospheric conditions do not seem to have been satisfactory at South Kensington, when these stages of Nova Persei occurred; but they show themselves beautifully in the Stonyhurst spectograms. Father Sidgreaves, the eminent astronomer of Stonyhurst, has stated:—"That he has no doubt at all but that Nova Persei actually was the third body, torn from a pair of colliding suns." He is quite opposed to the opinion expressed by some astronomers in *The Times*, that the phenomena of Nova Persei might be thought to be explained by the idea of a dense body passing into a nebula. He says the light could not grow up so suddenly. It would take an ordinary star fully a thousand years to pass from the outside to the centre of the Nova Persei nebula, whereas Nova Persei rose to a maximum in less than two days. This rapidity of formation renders it certain that if Nova Persei was the result of any kind of collision, it must have been the collision of compact bodies. There are fully a dozen other points of coincidence between deduced and observed spectral phenomena, but there are two that are extremely interesting and about which we must say a few words. For various physical reasons, already hinted at, I assumed that the ends of the spindle would consist of elements having atomic weights approximately that of iron and titanium, and because iron was a very abundant element in nature, I thought that the spindle ends would largely be made up of iron. Of course, the speed of the iron molecules would be much less than that of hydrogen, but as hydrogen was not escaping from the ends of the spindle, the iron would not have its kinetol lessened, and because its light would not pass in front of the nucleus, save under very exceptional conditions, the lines of iron would not have a shadow band on the end towards the violet, and would be moderately broad, yet not as broad as hydrogen. Figure 7 (given on page 365) shows part of a South Kensington spectrogram, a set of

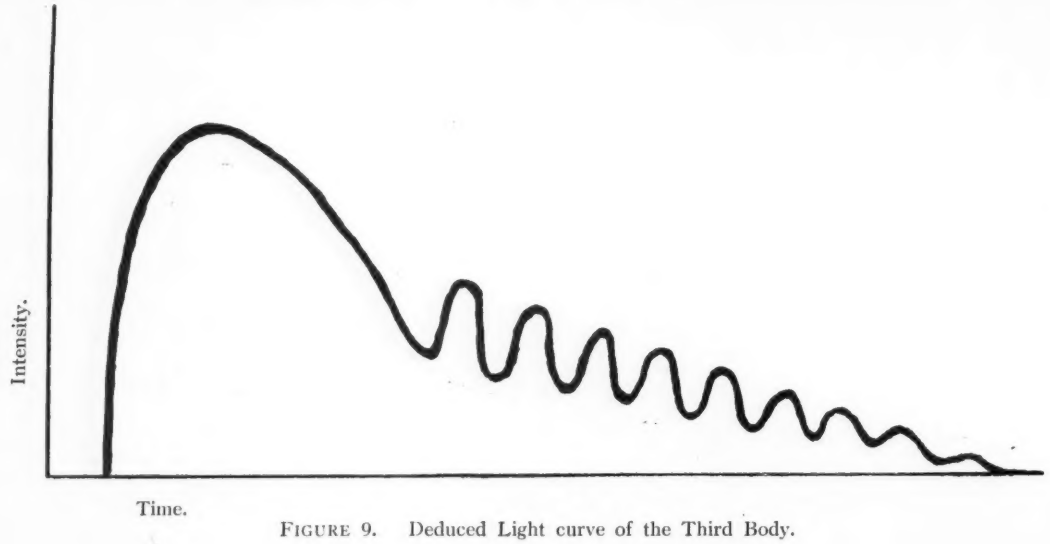

FIGURE 9. Deduced Light curve of the Third Body.

exactly such lines. On inquiry I ascertained from the observers at South Kensington that many of these lines certainly did come from iron, and there were also some that came from titanium.

The observers at South Kensington noticed a remarkable fact with regard to the broad hydrogen lines. They seemed streaky; towards the edges there seemed to be especial bands of greater intensity. In the theory of the third body, I have shown there is a line along which, in both directions, gas will be extruded. Axial Extrusion is the name we have given to this phenomenon. In the study of the origin of the universe, it is assumed to account for the origin of the white polar nebula that is distributed at each of the poles of the Milky Way. This principle also permits the hydrogen gas that is compressed at the centre of the third body to be expelled in the two directions polar to the plane of rotation. Doubtless it is these two vast streams of ejected hydrogen that give these two ribbons of intensity on the broad hydrogen bands. The observers at South Kensington also noticed minor ribbons of luminosity, and a careful study of the form of the third body shows other weak places, where, in a less effective way, hydrogen may be sent out as vast streamers.

There are quite a sheaf of other points of interest and coincidences, and some show themselves in connection with the pre-existing more or less annular spiral nebula that was lit up by the flash of Nova Persei, and that showed itself progressively in extending circumferences. Light, with its speed of one hundred and eighty-six thousand miles a second, for months progressively lit up the coils of that stupendous nebula, which I believe had been left behind in a previous impact of the same two gigantic suns, that by recurrent impact had produced the flash of Nova Persei. Deduction suggested also that extruded gas from the third body should generally pass through the stage of being a planetary nebula. And here, again, we have the same coincidences, but our account is already too long and we must conclude by stating that from its extreme brilliancy and its evanescence, Nova Persei was almost certainly formed by a very small ratio graze of two extremely massive suns, whilst Nova Aurigae was a moderately-deep graze of suns of much smaller mass. In the next number the coincidences of astronomical phenomena, with the deductions relating to the two torn suns, will be debated.

CYTOLOGY AND EMBRYOLOGY IN THE ENCYCLOPAEDIA BRITANNICA.

THE scientific articles in the last edition of "The Encyclopaedia Britannica" cannot fail to be of the greatest interest to the readers of this journal. They are clear and concise, and thoroughly up-to-date. That on Cytology, is of the highest importance, for "it is to the cell that the study of every bodily function sooner or later drives us." Space will only permit us to refer to one of the many interesting points elucidated in this article. Various views have been expressed as to which of the complicated processes which take place during nuclear division is fundamental and initiative. "The experiments of T. H. Morgan and E. B. Wilson, in which numerous centrosomes and asters are caused to appear in unfertilised sea-urchin eggs by a brief immersion in a 13 per cent. solution of magnesium chloride in sea-water, as also the possibility in many cases that even in normal fertilisation the cleavage centrosomes may arise *de novo*, make it no longer possible to regard the centrosome as a permanent cell-structure." "In the spermatogenic cells of *Ascaris*, A. Brauer has shown that the chromatin granules divide while still scattered over the nuclear reticulum and before either the formation of a spireme thread or the division of the centrosome." Clearly then, the formation of the achromatic spindle has for its purpose, not the division of the chromatin, for this has already occurred, but its distribution to the two daughter nuclei.

The article on Embryology is likewise full of interest. The question of the determination of sex has been much debated, but the balance of evidence, we are told, appears to favour the view that sex is an unalterable inborn character and does not depend on nutrition or other external condition. "Thus those twins which are believed to come from a splitygote are always of the same sex, members of the same litter which have been submitted to exactly similar conditions are of different sexes, and all attempts to determine the sex of the offspring in the higher animals by treatment have failed."

Various structures and organs appear during development to disappear again without representation in the adult form, but the writer of the article on Embryology gives little quarter to the recapitulation theory which attempts to explain this by asserting that the embryonic history of the individual is but a shortened Recapitulation of the ancestral history or history of the race. "A disappearing adult organ is not retained in a relatively greater development by an organism in the earlier stages of its individual growth unless it is of functional importance to the young form." Gills, for instance, are retained in the tadpole while they are lost in the frog, because they are of use to the tadpole, that is, to the larval form. Where organs are retained in a better developed state in the embryo than in the adult, it is simply because they have been of use to the ancestors in their larval form, though of no use to them in the adult, and have become in this way impressed upon their development; and only if they have been of value to the larval form in former generations is there any possibility of their retention.

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REVIEWS.

CHEMISTRY.

Triumphs and Wonders of Modern Chemistry.— By GEOFFREY MARTIN, B.Sc., M.Sc., PH.D. 358 pages. 76 illustrations. 8-in.×5¼-in.

(Sampson Low, Marston & Co. Price 7/6 net.)

No one need accuse Chemistry of being a dry subject after reading this book of Dr. Martin, with its wealth of illustrative detail and its power of stimulating the imagination of the reader. Obviously it has not been written with the aim of scoring marks in the examination schools, and the author is therefore at liberty to dwell upon matters of interest which would not "pay" if regarded from that utilitarian point of view. There is nothing in the book that need be beyond the grasp of those who have no previous knowledge of chemistry, while the chemist may learn much by reading the author's vivid descriptions of the most recent chemical theories and their industrial applications.

The book opens with a chapter upon the mystery of matter, in which are ably summarised the principal theories as to nature of the atoms, and this is followed by chapters dealing with the properties of the atoms, the evolution of the elements, and the nature of chemical reaction.

Then come separate chapters upon water, air and some of the principal elements, including hydrogen, oxygen, nitrogen, sulphur, carbon and phosphorus, and the book concludes with an admirable account of fire, flame, and the principles of spectroscopic examination. As instances of the manner in which the book has been brought up-to-date it may be mentioned that the latest theories upon radio-activity are discussed, and that there is a capital description with illustrative photographs of the industrial methods of fixing nitrogen from the air.

Quotations from the poets and from the whole range of ancient and modern literature are found in plenty all through the book, and help not a little in the author's successful endeavour to make the science a living thing. If we may venture upon a criticism, however, we cannot help feeling that in many cases the author's illustrative analogies fall wide of the mark. For example, the comparison between the combinations of atoms in a chemical reaction with the coming together of the partners in a ballroom appears forced, and does not help to make the subject any clearer. The book is abundantly illustrated with excellent photographs, and with numerous sketches. It is a pity that most of the latter are out of drawing and in a future edition the author would be well advised to have them redrawn by an artist.

These are minor drawbacks, however, and taking the book as a whole we can warmly recommend it either as a present that will give pleasure to a boy or a girl, or as a reliable and most readable source of information for everyone who is anxious to know something of the constitution of the world in which we live.

C. A. M.

The Phase Rule and its Applications.—By A. FINDLAY, M.A., D.Sc. Text Books of Physical Chemistry. 356 pages, 134 illustrations. 7½-in.×5-in.

(Longmans, Green & Co. Price 6/-.)

For the information of the non-chemical reader it may be explained that according to the *phase rule* of the late Professor Gibbs, the conditions of equilibrium in a given system of substances depend upon the relationship between the number of phases and of components simultaneously present. For example, ice, water and water vapour are different *phases* of the same substance—water, and may co-exist as different phases in a system.

When first the phase rule, which has proved so fruitful of result in the study of solution and chemical reaction, was enunciated, it was expressed in such mathematical terms as to be grasped only by those with a mathematical training, and the author of this book is to be congratulated upon the very lucid way in which he has presented a complex subject in a non-mathematical shape. Every step is made abundantly clear and each difficulty is smoothed away, and the student of chemistry or metallurgy whose work involves a knowledge of this branch of physical chemistry cannot do better than procure a copy of this exceedingly useful text book. It has deservedly reached its third edition, and has been brought up-to-date, so as to embody the results of the most recent researches upon such subjects as the metastability of metals.

C. A. M.

BOTANY.

British Plants—Their Biology and Ecology.—By J. F. BEVIS, B.A., B.Sc., and H. J. Jeffery, A.R.C.Sc., F.L.S. 334 pages. 115 illustrations. 5½-in.×8¾-in.

(Alston Rivers. Price 4/6 net.)

Botany, possibly because of its general popularity, suffers by reason of many students restricting their attention to morphology, and paying but little heed to the physiology of plant life. To enable botany to take its proper place in education it must be regarded as a branch of biological science and the struggle between the plant and its environment must be studied.

Messrs. Bevis and Jeffery have produced a book which supplements the elementary text-book and the flora, and assists the student to associate form with function and function with environment. The first part deals with the fundamental external factors—water, temperature, light, air and soil; then follows a physiological section in which plants are considered with regard to functional similarities. The final part is the most suggestive, dealing as it does with plant associations and the evolution and distribution of the British flora. A careful study of this book will give the student a new point of view and a new interest in solving the various problems concerning the habitat of plants as well as the aggregation of individuals into communities.

H. H. P.

NATURE STUDY.

Methodical Nature Study.—By W. J. CLAXTON. 195 pages. 20 plates. Numerous figures. 6¼-in.×8¾-in.

(Blackie & Son. Price 6/-.)

One of the objections which those who wallow in the academical rut have to Nature Study is that it is not systematised sufficiently to fall in with their ideas. The title of the book under consideration should therefore please them though too much method in Nature teaching would destroy most of its advantages. In so far as the recurrence of the seasons is followed, and continued observations on the same material is advocated, Mr. Claxton's book is to be commended. The general treatment is a little too much like botanical and zoölogical text books in places; in others it is very sketchy, and occasionally inaccurate. What does the author mean by the mollusc's tongue being in a very rudimentary state? For it is a most effective instrument, as the gardener only too well knows. We should like also to know why the carnivorous slug *Testacella* should be "a great pest in a garden which contains dahlias." No doubt teachers will get

a good many suggestions from the book, which is illustrated by numerous line drawings, and many familiar photographs by Messrs. Charles Reid, Henry Irving and Douglas English.

W. M. W.

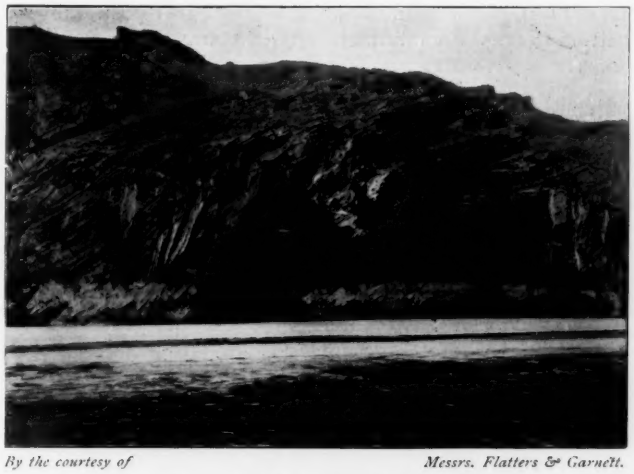
GEOLOGY.

The Mineral Industry of Rhodesia.—By J. P. JOHNSON. 90 pages. 1 plate. 9-in. × 6-in., interleaved.

(Longmans, Green & Co. Price 8/6 net.)

This is an account of the present stage of development of the Rhodesian mining industry. Gold is, of course, the most important mineral, and 609,960 ounces of the value of £2,568,200 were mined in 1910. A brief account of all the principal producing and developing mines in 1910 is given, with notes on the mode of occurrence of the gold. It is everywhere found near the contact of the basement granite with the sedimentary and other rocks into which it intrudes. Whilst gold is the mainstay of the mining industry, many of the other metals are becoming increasingly important, and the geology indicates great future possibilities for them. Many non-metallic minerals are also mined, including diamonds and coal. An excellent chapter on hints to prospectors concludes the book, which should prove valuable both to the men on the spot, and those otherwise interested in the rich mineral industry of Rhodesia.

G. W. T.



By the courtesy of *Messrs. Flatters & Garnett.*

Tremadoc Beds near Criccieth.

Notice the curved strata and the marine denudation along the bedding and joint planes.

Field Note Book of Geological Illustrations.—By HILDA D. SHARPE. 51 pages. 86 photographs and 2 maps. 9-in. × 6-in., interleaved.

(Manchester: Flatters & Garnett. Price 3/- net.)

This book consists entirely of photographs intended to illustrate the geological features seen by students during excursions or when on holiday, and to assist them to recognise in the field the facts which have been discussed in class. Each photograph is accompanied by a short descriptive note, and while most of them will doubtless be illustrative to the student, there are a few, such as the "Wyche Cutting, Malvern," which convey little or no geological information. Some others have either been poor photographs or have suffered in reproduction. The book is interleaved and is provided with a number of blank pages at the end for notes or for the insertion of photographs.

G. W. T.

Pebbles.—By E. J. DUNN, F.G.S. 198 pages. 76 plates. 9-in. × 6-in.

(Melbourne: G. Robertson & Co.)

The Director of the Geological Survey of Victoria has made good use of the fund presented to him along with the Murchison Medal by the Geological Society in producing this interesting book. He discusses exhaustively the form, material, shaping and transport of pebbles, and illustrates their endless varieties in seventy-six beautiful plates containing two hundred and fifty figures. Pebbles form an intermediate stage between boulders riven by various agencies from their parent rock, and the sand or mud to which they are ultimately reduced. Their story, as told by Mr. Dunn, is a veritable romance of science. The first seven plates illustrate the history of pebbles as they pass from angular boulders, through sub-angular and rounded pebbles, to fine sand, in a most graphic manner. A final chapter is devoted to the uses of pebbles by man as tools, weapons, sinkers, weights and sacred objects.

G. W. T.

PHILOSOPHY.

Creative Evolution.—By HENRI BERGSON. Authorized translation by ARTHUR MITCHELL, Ph.D. 425 pages. $8\frac{3}{4}$-in. × $5\frac{3}{4}$-in.

(Macmillan & Co. Price 10/- net.)

Professor Bergson's philosophy is well deserving of the very widespread interest that it has aroused. One can say this without necessarily agreeing with his views. For what Bergson has to advance are really new ideas; and if new ideas are not always true ideas, they are always valuable as stimulants to thought. In the present case, moreover, it can hardly be denied that there is a large element of truth in Bergson's arguments, and that he puts forward a new way of viewing the problems of life and philosophy, which in itself is both valuable and useful; add to this a style which almost persuades one against one's will even where views the most novel are advanced. In parenthesis, let us further add that the work of translation appears to have been done in a most careful and satisfactory manner, Professor Bergson himself having revised the whole work.

Reality, so we understand Bergson, is Becoming. Concrete time is the stuff of reality; reality creates itself gradually, fundamentally it is absolute duration. Life transcends intellect, and thus it is only by the synthesis of intellect with instinct, or intuition, the two end products of the evolution of life in opposite directions, that a true philosophy of life is forthcoming. Life is the outcome of an impetus given once and for all; it is free and thus creates as it evolves. Materiality and intellectuality are the results of the inverse movement to that which is life. Both radical mechanism and radical finalism are erroneous, but the former more emphatically so than the latter. Bergson's arguments are splendid; but we doubt whether he has really proved that concrete time is fundamental reality, the creative force in evolution; and if time be not this, but merely a way we have of regarding phenomena—in a word, a mode of consciousness—Bergson's arguments against finalism will not stand. Moreover, it is difficult to conceive of life as the result of an impetus given once and for all. Not only do we ask, whence derived? but why given then and not at some other time? Was this the beginning of time, or if not, what sort of time preceded it? The difficulties are largely removed if one considers life as, in its origin, transcending time, but in its manifestations contemporary with infinite time.

The confines of a necessarily brief review do not permit of even a satisfactory outline of Bergson's philosophy, so many new ideas and ways of thinking does it contain; still less, then, do they permit of any adequate criticism of this system. All we have attempted above is to present some of its salient features. In conclusion, let us say that all those who desire to keep abreast of modern thought will certainly read this book, and will do so with interest and enjoyment.

H. S. REDGROVE.

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NOTES UPON THE FUNDAMENTAL SYSTEM OF STARS.—ADDENDUM.

By F. A. BELLAMY, M.A., F.R.A.S.

JUST as the second part of the article on "Notes upon the Fundamental System of Stars" was passed for Press, I received from Professor Boss, in response to my request, some additional information referring to certain details which brought the subject of those notes quite to date. This addendum will therefore serve both to include these, and to make one or two corrections.

The letter "s" should have been used instead of "*z*" for San Luis throughout the article: the final "s" is sounded as the English "*z*."

The only meridian circle at the Dudley Observatory is that known as, and inscribed on the cube "Olcott Meridian Circle." It was presented to the Observatory by Mr. Thomas W. Olcott, President of the Trustees at that time, and was made by Pistor and Martins, Berlin, in 1856; it is eight inches in aperture and one hundred and ten inches focal length, not ten feet.

Since 1904 various grants have been made to the Dudley Observatory from the funds of the Carnegie Institution of Washington, and in the more recent years a sum of four thousand pounds to seven thousand pounds each year.

Previously to the connection with the Carnegie Institution the Dudley Observatory had produced a catalogue of about ten thousand stars, eight thousand being between declinations $-20°$ and $-37°$, to the 7·5 magnitude, and these observations were made in the years from 1896-1901. This work is in catalogue form, but is not yet published.

While this work was in progress, and especially in 1901, after observations upon it had been completed, Professor Boss undertook a comprehensive work concerning all the stars visible to the naked eye from the northern to the southern pole. The object of this work was to ascertain, with the greatest possible accuracy, the proper motions of each of these stars. Also included in this were all stars, of whatever magnitude, that had been accurately observed previous to 1855. It was this work that the Carnegie Institution of Washington began to aid in 1904. The scheme, though an exceedingly extensive and laborious one, was regarded as preliminary to a larger one that is now in progress at the Department of Meridian Astrometry of the Carnegie Institution of Washington. It may be remarked, as it is not generally understood, that this and the Dudley Observatory, Albany, N.Y., are essentially one.

The result of this preliminary work, just referred to, has been published under the title of a Preliminary General Catalogue, formed from various sources. It contains the positions of six thousand one hundred and eighty-eight stars reduced to the epoch 1900, and it includes the results for the primary design of computing proper motions from a collection, as complete as possible, of all accurately observed star-positions made during the history of Astronomy, each authority being systematically corrected to make it homogeneous with the mean of all the most reliable observers.

On the arrival of the second expedition, in February, 1909, the piers were ready, and the instruments were carefully mounted, adjusted, and the principal constants were investigated during the month of March—naturally as the consequence of very strenuous exertions.

There were usually two sets of observers for each night. In each set there was the principal observer at the telescope, and an assistant to read the four microscopes for each star. One set observed at intervals from about 4 to 7.30 p.m., then continuously to about 11 p.m., and again for about an hour near sunrise. The other set observed from about midnight to 4.30 a.m. The observations were pushed unremittingly in this manner until the end. Additional assistants, Messrs. Mearns and Jenkins, arrived in San Luis in September, 1909. There were always seven observers, and for a short time ten observers.

In the first twelve months from April 6th, 1909, nearly sixty thousand complete meridian observations were secured. For observations of this class, this record has only been approximately approached at Cordoba, Argentina, under the direction of the late Dr. B. A. Gould, where in one year about forty thousand meridian observations were obtained.

The meridian observations at San Luis were completed in January 1911, and the members of the staff returned to the United States in February and March. They secured in all about eighty-seven thousand observations, upon about fifteen thousand stars including all the stars south of declination $-20°$ noted as of the seventh magnitude or brighter, all of the Lacaille stars, and all the stars accurately observed, previous to 1860, at the principal observatories in the Southern Hemisphere. These stars were each observed four or more times. About two thousand standard stars were each observed from eight to forty, or more times.

In addition to the great work which these eighty-seven thousands of straightforward observations entailed, very extensive researches of immense importance to accurate fundamental meridian work were carried out to determine the general and daily constants of the instrument, in order to facilitate the reduction of the star-observations in an accurate and systematic form. These reductions are now in

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progress at Albany with a large force of computers, so that astronomers will not have to wait many years, as is usual with most meridian work, before the catalogue is published: Professor Boss believes in expeditious work.

In the summer of the present year it is anticipated that the Olcott meridian circle will be again installed and ready for work at the Dudley Observatory, Albany. The standard stars will be again observed as already described, and, later on, the observation of all the stars down to the seventh magnitude that are north of $-20°$ will be undertaken.

I will conclude these "Notes," by a quotation from a letter from Professor Boss to me:—"The last observation was taken (at San Luis) on Jan. 30, 1911. This work has been accomplished at a rate far beyond my anticipations. The great prevalence of clear nights—two hundred and eighty *per annum*—the large force of observers—seven to ten, and the resistless zeal of the staff are responsible for this." As an old meridian-circle observer it is pleasant to read this appreciation of the observer's work, which, somehow, has usually escaped inclusion in the introductions to observatory star catalogues.

THE ASTRONOMY SECTION AT THE CORONATION EXHIBITION.

THE admirable principle of devoting a section of a large exhibition to Science, which was first instituted at the Franco-British Exhibition at the White City, in 1908, and repeated at the Japan-British Exhibition last year, has received increased development at the Coronation Exhibition this year. Much might be said of the exhibits in the several branches of Science there shown, but our present remarks must be confined to those in the section devoted to Astronomy.

These exhibits are deserving of more than a passing notice, as they embrace some of the most recent results in astronomical research. They consist generally of a collection of old astronomical instruments, models, and photographs of celestial phenomena.

Many of the instruments have been exhibited at previous exhibitions—notably the very fine and varied collection of Astrolabes, Quadrants, Nocturnals and Dials shown by Mr. Lewis Evans. Seeing that such were the only instruments possessed by astronomers for many centuries for determining the positions of the heavenly bodies and for giving the time, it is interesting to examine the differences in construction and estimate the very limited accuracy that was possible with such instruments. Mr. Evans shows Oriental and European Astrolabes dating from the fourteenth to the seventeenth centuries, and a large collection of Sun Dials and Quadrants of the sixteenth and seventeenth centuries. In this connection there is a very interesting exhibit from Gonville and Caius College, Cambridge, of an astrolabe presented to the College by John Caius, one of its founders—the case of which is richly embossed and of peculiar beauty. Four examples are exhibited of the Davis Quadrant or Back Staff, one of which is shown by Mr. Lewis of the Royal Observatory, Greenwich, who has contributed a very interesting account, with a drawing, of the method of using it. From this we learn that the Back Staff was invented by Captain John Davis, in the year 1590, previous to his sailing for the South Seas. Before that time the only means of measuring the altitude of the sun was with a simple quadrant, such as the very fine specimen by Magini, shown at the Exhibition. The arc of the Davis quadrant was divided into degrees, and had in addition a Gunter's scale for subdivisions. A Vernier was not applied till about 1618. Some fifteen years later Elton, the clockmaker, added an index arm on which he placed a level which made the observer independent of the horizon. A further improvement was made sixty years later by Flamsteed, who added a lens to the instrument, and thus it was used until Hadley invented his quadrant in 1730.

Perhaps the most interesting exhibits in the Astronomy Section are those contributed by the Royal Observatory, Greenwich, which embrace two models of remarkable interest. The first is a model of the orbit of Jupiter's Eighth Satellite, showing the path of the satellite round Jupiter from the time of its discovery in 1908 to the year 1916, predicted from observations made in 1908 and 1909, by a method devised by Dr. Cowell, the necessary calculations being made by Dr. Crommelin. It is doubtful whether an astronomical model so instructive as this has ever been constructed. The path of the satellite is indicated by wires supported by pillars at every three hours of Jovicentric Right Ascension. The path of the satellite from 1909 to 1910 is shown by a different coloured wire for each year. It will be remembered that the motion of the satellite is retrograde—the mean sidereal period of revolution is nearly two years—the mean distance is fourteen millions of miles and the mean eccentricity 0·38. The result of this great eccentricity is that the distance of the satellite from Jupiter varies from eight to twenty-one million miles, and the Greenwich description of the model states that it is possible for the eighth satellite to be nearer to its primary than the seventh. The model gives also the orbits of satellites thus VI. and VII. and the five inner satellites to scale in their proper phase. The scale of the model is eighty inches=one solar unit, or one inch=one million and one hundred and sixty thousand miles.

The second model referred to is that of a star cluster in Taurus which has been shown by Professor Boss to form a connected group of stars moving through space in the same direction and with a common velocity. The exceptional interest that attaches to this model warrants us in appending the description of it given by the Royal Observatory. "This model represents a cluster of bright stars which is comparatively near the earth. The group covers an area in the sky fifteen by fifteen degrees, and is situated in the region of the Constellation Taurus. From a study of their Proper Motions, Professor Boss has shown that they form a connected cluster of stars, moving with a common velocity and in parallel directions. The present position of the Sun, with regard to the cluster, is shown by the large white ball placed at the end of the arm projecting in front of the model, the plane of the base board being that of the Earth's Equator. The wire along which the white ball runs represents the path traversed by the Sun (or the parallel to that traversed by the cluster; for we may consider the Sun to be moving past the cluster, or the cluster past the Sun). The small column to the left of the model indicates the position of the Sun eight hundred thousand years ago. At the present time the distance of the Sun from the centre of the cluster is eight hundred billion miles, or (say) eight million times the distance of the Earth from the Sun. Relatively to the Sun the cluster is moving at a velocity of twenty-eight and a half miles per second, a velocity which will carry a star eight and a-half times the distance of the Earth from the Sun in a year. The distances of the stars in the cluster from their nearest neighbours are much the same as the distance of the Sun from its nearest neighbours, and all the stars in the cluster would be included in a sphere of one hundred and thirty billion miles radius. At present the stars are of magnitudes from three and a half to six and a half; after sixty-five million years the group will appear as a globular cluster about twenty minutes of arc in diameter, consisting of stars from ninth to twelfth magnitude. Of these forty-one stars, fourteen are white stars, whose spectra are like that of Sirius: the spectrum of the others show them to be in a somewhat more advanced stage, but only a few of them have reached the stage at which the Sun now is. They appear to be stars of great

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luminosity: three of them would be more than one hundred times as bright as the Sun at its distance; six between fifty and one hundred times as bright; twenty-two between ten and fifty times; and the faintest of the forty-one stars has five times the luminosity of the Sun. Out of the fourteen stars in a group, which have been examined with the spectroscope, eight have proved to be binaries. It is probable that quite a number (fifty) of fainter stars also belong to the cluster; but their Proper Motions are not as yet sufficiently well determined to be certain."

It is not too much to say that considering the care and exactitude with which they have been constructed these two models are unique.

There are exhibited in the Astronomy Section a large collection of photographs and transparencies contributed by the Observatories of Greenwich, Cambridge, Stonyhurst and the Cape, the Royal Astronomical Society and others. Among the most interesting is a very beautiful series of transparencies contributed by M. Deslandres, from the Meudon Observatory. These comprise some thirty spectroheliograms of the Sun in calcium and hydrogen light, showing the most recent and remarkable results obtained at that Observatory.

To understand the great advance that has been made in this branch of solar research in the last few years, it should be borne in mind that up to the year 1908, spectroheliograms of the Sun's surface were obtained with instruments of such moderate dispersion that the radiations from several layers in the solar atmosphere were integrated. As the lower layers are the more brilliant, the forms of the upper regions were more or less masked. The construction of a more powerful instrument at Meudon, has enabled M. Deslandres to satisfactorily isolate the light of the upper atmosphere from that of the lower strata. The results can be very well studied in the photographs exhibited. Numerous examples are shown taken in pure K3 light—the highest layer in the Sun's atmosphere yet examined. These are new, and the credit of obtaining them belongs to M. Deslandres. Comparing these with those taken in K2·3 light it is found they possess characteristics which distinguish them clearly from the lower layers. Striking examples are shown of the curious black markings called "filaments," and the connection of these filaments with solar prominences. Equally striking is the fact noted by M. Deslandres, that some of these filaments seem to form a zone round the poles. The photographs taken in hydrogen light are equally worthy of study. They show remarkable differences, according as they are taken with the centre or the borders of the Hα line.

Interesting photographs are exhibited taken with the "Spectroenregistreur des vitesses," that is, a spectro-heliograph of Velocities, which photographs the displacements of the spectrum lines in the line of sight for all points on the solar disc. The study of the results obtained with this new method of M. Deslandres shows that vapours are rising over the areas represented by the dark filaments, and descending over the areas represented by the bright faculae. Space does not allow of our giving a more detailed account of this exhibit which is deserving of close study.

The late M. Charles Emile Stuyvaert, of the Royal Observatory, Brussels, devoted the last ten years of his life to the construction, in wax, of a model of the moon which was almost completed at the time of his death in 1908. The model was made on a scale of one-millionth the natural size. One portion of it representing the Lunar craters Arzachel and Alpetragius is shown at the exhibition, and is one of a series of twenty-four similar models which represented the complete hemisphere.

On the whole, the science of Astronomy is fairly well represented at the Exhibition, not only in the list of those who have sent contributions, but from the fact that the exhibits may be considered in many respects as indicating the most recent advances in the science.

NOTICES.

NOTES OF A NATURALIST IN THE MEDITERRANEAN.—Mr. G. B. Hony asks us to point out that the date which was given in the August number for the appearance of Nightingales at Granada as March 10th should be May 10th.

A UNIQUE SUNDIAL.—Mr. J. A. Hardcastle writes to say that at his request Colonel W. G. Armstrong some time ago described a similar sundial to that of which Mr. A. Paul Monckton gave an account in the August number, in *The Journal of the British Astronomical Association*, and that Miss Agnes Fry has pointed out that there is one depicted in Holbein's picture of "The Ambassadors" in the National Gallery.

APPARATUS FOR ELECTRO-THERAPY AND DIAGNOSIS.—Messrs. W. Watson and Sons' new catalogue dealing with these subjects runs into nearly one hundred pages. Besides containing illustrations of all the most up-to-date coils and X-Ray tubes, screens and radiometers, it shows some interesting pictures of an improved intensifier screen called the "Sunic" for X-Ray work, by which the exposures are reduced by ninety-five per cent. The saving in the life of the tubes quickly repays the cost of the screen. The figure showing sciagraphs of a hand taken with an exposure of one twentieth of a second on a plate of which half only was covered with the screen, is very remarkable.

THE FÉRY REFRACTOMETER.—We have pleasure in announcing that Messrs. Adam Hilger, Limited, have introduced M. Féry's Refractometer and have issued a descriptive pamphlet with regard to this instrument which is a direct reading refractometer for taking the refractive index, for sodium light, of oils, solutions of acids, sugar solutions, mixtures of glycerine, alcohols and so on with water.

AN IMPROVEMENT IN THE MICROSCOPE STAND.—Messrs. R. & J. Beck have introduced an improvement in the shape of the stands of many of their microscopes which allows the limb of the microscope between the fine adjustment screw and the stage, to be grasped by the whole hand so that when the instrument is lifted none of the adjustments are altered. The same firm has put upon the market a grinding and polishing machine of a most compact nature for the purpose of making microscopical specimens for metallurgical work.

PRISM BINOCULARS.—Mr. E. Leitz sends us an illustrated list of his prismatic binoculars, which includes several new patterns. At one end of the series is an instrument giving a magnification of four diameters, which is used in the theatre while at the other end is a field-glass giving three times this magnification. There is a new glass also with a magnification of eight, which has an enlarged field of view and an improved stereoscopic effect. The latter is obtained by increasing the distance between the object glasses relatively to that between the eye pieces, and this, particularly at the range at which a student of natural history would require to use the glass, certainly assists vision.

MICROSCOPES AND ACCESSORIES.—Section one, Part one, of Mr. C. Baker's catalogue deals with the microscopes made by his well-known firm. Among special microscopes are the inexpensive ones designed for nature students and meat inspectors, while we may also mention the diagnostic microscope for the use of officers in foreign medical service for the diagnosis of malarial fever. A very similar model has also been designed for the use of travellers.

Parts two, three and four of the same catalogue are occupied by dissecting instruments, stains, mounted specimens for sale or hire and apparatus for collecting pond life.

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